



# TeraFlow

## Contents

EDITOR'S NOTE .....	2
TeraFlow – Project Updates .....	3
Highlights of the period .....	6
News & Events .....	7
Next Events.....	10
Other news .....	10
Papers .....	11
Meet TeraFlow Partners.....	12



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**5G** PPP



## EDITOR'S NOTE

Welcome TeraFlowers,

TeraFlow is a Phase 3 5GPPP h2020 project with the objective to research and develop the future of software defined networks for beyond 5G networks. Our main objective is the creation of a novel SDN controller for beyond 5G networks (TeraFlow OS).

This new SDN controller shall be able to integrate with current NFV and MEC frameworks as well as to provide revolutionary features for both flow management (service layer), and network equipment integration (infrastructure layer), while incorporating ML-based security and PDL-based forensic evidence for multi-tenancy. The TeraFlow OS will be the first of a new type of secured

cloud-native SDN controllers that will radically advance the SoA in software-defined networks.

This first newsletter presents our current work, while working on the first release of **TeraFlow SDN controller**. We expect that it provides you with the necessary information and in case you want to collaborate with us, please follow us on our social networks or get involved in upcoming events.

Thank you!

**Ricard Vilalta**, Project Coordinator



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[youtube.com/channel/UCz86mcBvscgA4tS\\_voXokyQ](https://www.youtube.com/channel/UCz86mcBvscgA4tS_voXokyQ)



[teraflow-h2020.eu](http://teraflow-h2020.eu)

# TeraFlow – Project Updates

## WP2 – Use cases, requirements, architectures, business models analysis and data models



The scope of WP2 is the definition of the use cases, requirements, architecture and data models for the TeraFlow OS. Moreover, it contains the techno-economic studies to cope with the impact of the solution and its feasibility for operator environments.

Based on the use cases, the requirements for the software components will be identified. Once the requirements are delivered, the effort will be focus on the architectural design. This approach will iterate with other WPs to obtain feedback and define the final set of use cases, requirements, architecture and data

models. The initial definition will have impact in standardization activities to cover all parameters required by the TeraFlow OS.

We have already detailed the selected scenarios and the studied use cases. These use cases have been used to elaborate functional and non-functional requirements, which help the design of the overall architecture, including all TeraFlow components. A first architectural design and data models have been delivered at the end of June 2021.

*Telefonica*

## WP3 – Life-cycle automation and high performance SDN components



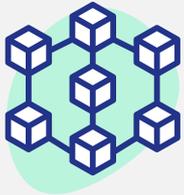
The scope of WP3 is to shape the core modules of the TeraFlow OS, thus building a novel SDN controller architecture that aims at capabilities and deployments beyond 5G networks. To do so, TeraFlow OS will bridge key gaps of state-of-the-art SDN controllers by:

- ❑ targeting ultra-high-performance flow processing (at least 10x higher than existing multi-instance controllers),
- ❑ providing data models for the most prevalent transport technologies (IP, optical ,and microwave) with a view towards beyond 5G systems,
- ❑ fully automating network service management, while supporting zero touch configuration for new devices' onboarding, and
- ❑ supporting multi-tenancy through advanced transport network slices, potentially across multiple domains, coupled with strict performance requirements and service-level agreements.

WP3 kickstarting activities include a SoA study and analysis of technical aspects of relevant SDN, Cloud-native and SDO solutions. This analysis will provide the fundamental technologies that the TeraFlow OS architecture will adopt, while highlighting key gaps to bridge towards beyond 5G cloud-native deployments. The natural continuation of this milestone is the design and implementation of the first version of the core TeraFlow OS components, following the suggested technologies. This work will provide the first proof-of-concept prototype of the TeraFlow OS by the end of October 2021.

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## WP4 - Network security and interworking across B5G networks



This work package targets the design and the development of the TeraFlow OS components that are essential for future network security. The main objectives of WP4 are summarized as follows:

- Advance the state of the art in core technologies (machine learning and blockchain). Identify and define relevant network attacks, in particular, ones for B5G networks. Provide TeraFlow with the necessary smart contracts to safely address a permissioned distributed ledger among several entities.
- Allow TeraFlow interworking with other components of beyond 5G networks such as NFV orchestrators, and edge and cloud resources. Also, include peer inter-domain establishment of smart connectivity services among multiple TeraFlow OS.

To structure this wide range of topics, WP4 comprises three tasks,

each dedicated to separate TeraFlow components together with their core technologies (Cyberthreat analysis and protection, Distributed ledger and smart contracts and Interworking across Beyond 5G Networks). The activities of each of these tasks started in May 2021

Preliminary work has been started in order to identify SoA components and mechanisms that will be used as the starting point for the proposed solutions. We are also identifying use cases in the resource allocation, forensic analysis and resource transportation areas, whose respective requirements are currently being defined. For both the compute integration and inter-domain Teraflow OS components, the work is focusing on seeking for candidate solutions as well as identifying the requirements in terms of APIs, workflows, embedded functionalities, etc.

**NEC**

## WP5: Prototype integration, demonstration and validation



The objective of WP5 is to create a TeraFlow OS software package ready for deployment and evaluate its performance. WP5 will integrate the software components developed by WP3 and WP4 into an initial TeraFlow OS prototype. The feasibility and performance of this prototype will then be tested via several experimental, validation, and evaluation activities. The testing and performance evaluation work carried out in WP5 will also trigger design updates following a continuous development/ continuous integration (CD/CI) methodology.

The work in the WP will leverage on three platforms: (i) the TID Future Network Lab (which features SDN-ready and interoperable IP, optical, and microwave (MW) equipment), (ii) the CTC ADRENALINE platform (which combines an SDN/NFV packet/optical

transport network and an edge/core cloud platform specialized for testing end-to-end 5G and intelligent transport system (ITS) services), and (iii) the TID MouseWorld environment (which integrates synthetic traffic generation with collection and labelling to train and validate AI/ML algorithms for the detection of cybersecurity threats).

The activities of WP5 started at the beginning of May 2021 and we have completed our first milestone (MS5.1) at the end of June 2021. The milestone provides an inventory of the testing facilities available for the project, describes the scenarios where the TeraFlow OS prototype will be tested and explains the continuous development/ continuous integration (CD/CI) setup.

**CHALMERS**  
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## WP6: Standardization, Dissemination and Exploitation



The objective of WP6 is to define the strategy and implement the related plans for the successful further use of TeraFlow results in order to maximise the impact of the project in and outside the consortium. In this WP, partners are working to make society aware of the project and its benefits (communication), telling the target audience about the project results and collecting their feedback (dissemination) and reflecting on how these results will be accessible in order to be used, by project's partners or third parties, beyond the project duration (exploitation).

As regards communication, the project is now in the raising awareness phase with different channels and tactics in place, like the project website, social media accounts and communication material with a brand image and visibility of the EU funding.

Related to dissemination, we have presented several papers and workshops to relevant conferences: four conference papers to OFC 2021, one to EuCNC 2021, one to ONDM 2021 and two demo papers for OFC 2021, as well as a workshop proposal and special session for EuCNC 2021, details can be found in the News&Events section of this newsletter, where you can also read about the events where TeraFlow has participated to date and the plans for next months. The project has also nominated representatives to participate in 5G PPP WGs activities

with a special focus on Architecture, Software Networks and Security. Regarding contribution to standards, we are very active in ETSI ISG PDL (already being part of PDL work items MI/PDL007 and GR/PDL-008), ETSI ISG ZSM (studying the feasibility to run a Proof-of-Concept based on ZSM006-PoC Framework), ETSI mWT ISG, Telecom Infra Project, ONF, IETF, ITU-T Focus Group on Autonomous Networks and OpenConfig.

Finally, in the exploitation activities, we aim at contributing with TeraFlow SDN controller to the Open Source community but, willing to allow other business models, we are also considering that the released TeraFlow SDN Controller will not include some advanced characteristics that might be exploited in a freemium model. Apart from this, contributions to other open source projects like ETSI Open Source MANO, ONF ONOS, Hyperledger and Free Range Routing are also envisaged.

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# Highlights of the period



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## Network Slicing with the Internet Engineering Task Force (IETF)

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The term “Network Slice” has existed for decades but has grown in popularity in recent years due to 5G. Several use cases present themselves that would benefit from network connections capable of meeting a specific set of objectives concerning network resources use - this connectivity and resource commitment is referred to as a network slice. Within the TeraFlow project, a network slice is a crucial concept, and there has been a need to define the concept in more detail.

TeraFlow project partners are helping coordinate network slicing work within Standards Development Organisations, including editing and coordinating the vital Internet Engineering Task Force (IETF) document “[Framework for IETF Network Slices](#)”. This document will propose a

general framework for requesting and operating IETF network slices and their characteristics, essential definitions, the necessary system components and interfaces, and how abstract requests can be mapped to more specific technologies. Furthermore, the document will also discuss monitoring and security considerations.

We will report in the future on the progress of this activity and how it relates to the TeraFlow project, its objectives and deliverables.

# News & Events

FIND HERE THE MAIN HIGHLIGHTS OF TERAFLOW DISSEMINATION AND COMMUNICATION ACTIVITIES WITHIN THE BEGINNING OF THE PROJECT AND JUNE 2021!



## 3rd ONFIRE Symposium

24 Feb | Virtual event

TeraFlow project was showcased within the presentation "*Optical white boxes design and programmability adopting GNPpy*" held by Victor López from Telefónica I+D. The presentation focused on showcasing work and findings partially supported by the TeraFlow project. [➔](#)



## TIP OOPT MUST: Operators Driving SDN for Transport Adoption and Acceleration

3 Mar | Virtual event

This event formally introduced the Telecom INFRA Project - Operators Driving SDN for Transport Adoption and Acceleration - Mandatory Use Case Requirements for SDN for Transport (TIP OOPT MUST) subgroup, providing a view to the optical industry of what this subgroup will achieve. Work related to TeraFlow was presented by Victor López from Telefónica I+D. [➔](#)



## OSM Ecosystem Day

10 Mar | Virtual event

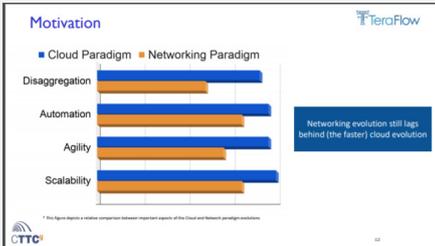
The event aimed to share how OSM is helping organisations in its ecosystem to achieve their goals. Within the event, Dr. Ricardo Martínez, Senior Researcher at CTTC presented "TeraFlow in the OSM ecosystem" focusing on the adoption and integration of the OSM within the project solution. [➔](#)



## 5G-PPP Webinar: Europe accelerates towards 6G

16 Mar | Virtual event

Organised by the 5GPPP, the webinar introduced the 9 new 5G-PPP Smart Connectivity beyond 5G projects which since January 2021 are developing exciting advances beyond 5G towards 6G. Represented by our project coordinator, Ricard Vilalta from CTTC, shared TeraFlow's vision of 6G, our motivation and technical challenges we are addressing to enable 6G. [➔](#)



## Presentation “Software define control of optical networks” @UPC – EETAC

17 Mar | Virtual event

TeraFlow’s Project Coordinator, Ricard Vilalta from CTTC was invited to have a talk during a seminar for master’s students in Applied Telecommunications and Engineering Management from Universidad Politecnica de Catalunya - Castelldefels School of Telecommunications and Aerospace Engineering (EETAC). His presentation “Software-defined control of optical networks” focused on the current scenario of optical networks and how TeraFlow’s approach will bridge the gaps of state-of-the-art SDN controllers by providing multiple capabilities. ➔



## CodeBeam STO 2021

19 May

TeraFlow project is developing a distributed Software-Defined Network (SDN) controller targeting a tera of managed flows in beyond 5G networks. In this tech talk, after an overview of what is Software Defined Networking, Traffic Engineering, and the protocols involved, Sébastien Merle from Stritzinger introduced TeraFlow’s architecture, the concerns, constraints, and challenges encountered. To finalise, he performed a live demo showing the progress so far and presented the open-source projects created or improved as part of the development. ➔



## The Optical Networking and Communication Conference & Exhibition (OFC 2021)

6-11 Jun | Virtual event

The premier event in telecom and data center optics, considered the hub of the industry as it represents the entire ecosystem—from research to marketplace. The event had technical sessions and a virtual exhibition featuring industry-focused programs and projects such as TeraFlow. Within the event, 4 papers and 2 demo papers were accepted and presented. ➔



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## EuCNC & 6G Summit 2021

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8-11 Jun | Virtual Event

The 2021 Joint EuCNC & 6G Summit, builds on putting together two successful conferences in the area of telecommunications: EuCNC (European Conference on Networks and Communications), in its 30th edition of a series, supported by the European Commission; the 6G Summit, in its 3rd edition, originated from the 6G Flagship programme in Finland. The conference is sponsored by the IEEE Communications Society and by the European Association for Signal Processing, and focuses on all aspects of telecommunications ranging from 5G deployment and mobile IoT to 6G exploration and future communications systems and networks, including experimentation and testbeds, and applications and services. Within this event, 1 paper, 1 special session and 1 workshop were held by TeraFlow and its consortium. [→](#)



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## ONDM 2021

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28 Jun - 1 Jul

The 25th International Conference on Optical Network Design and Modelling (ONDM 2021) has been organised by the Chalmers University of Technology from the 28th of June to the 1st of July 2021. ONDM 2021 addresses cutting-edge research in established areas of optical networking and their adoption in support of a wide variety of new services and applications. TeraFlow is organising a 2-hour workshop with the title: "Micro-service based autonomic traffic control in 5G and beyond". [→](#)



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## Mobile World Congress

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28 Jun - 1 Jul | Hybrid

Considered the industry's most influential and important event, MWC Barcelona attracts some of the most relevant decision makers in the world. TeraFlow was there at CTTC booth, represented by our Project coordinator Ricard Vilalta, who could demonstrate the main concepts of the TeraFlow SDN controller to the interested audience. [→](#)

## Next Events

### NGON & DCI World

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#### NGON 2021

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30 Sept | Virtual Event

NGON addresses optical innovation and drive towards Terabit transmission with a smarter and more flexible exhibition and conference. The project is organising a workshop in this event "TeraFlow: Utilizing Optical Network Slicing to Connect Clouds for Autonomic 5G and Beyond Services". The session will consist of three presentations and a panel session. Topics/content include: - Overview of the TeraFlow Project and Stakeholders - SDOs Enabling Optical Network and IT Convergence - Optical Network Automation and Slicing Techniques - Deploying and Integrating Automated Optical Network Slicing - Examples of 5G Application and Services - Future Challenges and Opportunities. [➔](#)

## Other news

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#### TeraFlow 1st Press Release

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"EU-funded project TeraFlow to develop a novel and secure cloud-native SDN controller for beyond 5G networks". [➔](#)



# Papers

## **“End-to-End Network Slice Stitching using Blockchain-based Peer-to-Peer Network Slice Managers and Transport SDN Controllers”**

*Pol Alemany\*, Ricard Vilalta, Raul Muñoz, Ramon Casellas and Ricardo Martínez*

## **“First Scalable Machine Learning Based Architecture for Cloud-native Transport SDN Controller”**

*Carlos Manso, Noboru Yoshikane, Ricard Vilalta, Raul Muñoz, Ramon Casellas, Ricardo Martínez, Cen Wang, Filippos Balasis, Takehiro Tsuritani, Itsuro Morita*

## **“Multi-layer Transport Network Slicing with Hard and Soft Isolation”**

*A. Alcalá, S. Barguil, V. López, L.M. Contreras, C. Manso, P. Alemany, R. Casellas, R. Martínez, D. González-Pérez, X. Liu, J.M. Pulido, J.P. Fernández-Palacios, R. Muñoz, R. Vilalta*

## **“Autonomous Security Management in Optical Networks”**

*Carlos Natalino, Andrea Di Giglio, Marcho Schiano, Marija Furdek*

## **“Blockchain-Based Connectivity Provisioning in Multiple Transport SDN Domains”**

*Pol Alemany, Ricard Vilalta, Raul Muñoz, Ramon Casellas, Ricardo Martínez*

## **Demo paper: “Scalable for Cloud-native Transport SDN Controller Using GNPY and Machine Learning techniques for QoT estimation”**

*Carlos Manso, Ricard Vilalta, Raul Muñoz, Ramon Casellas, Ricardo Martínez*

## **Demo paper: “Operationalizing partially disaggregated optical networks: An open standards-driven multi-vendor demonstration”**

*E. Le Rouzic, A Lindgren, S. Melin, D. Provencher, R. Subramanian, R. Joyce, F. Moore, D. Reeves A. Rambaldi, P. Kaczmarek, K. Weeks, S. Neidlinger, G. Agrawal, S. Krishnamoha, B. Raszczyk, T. Uhlar, R. Casellas, O. Gonzalez de Dios, V. Lopez*

## **“TeraFlow: Secured Autonomic Traffic Management for a Tera of SDN Flows”**

*Ricard Vilalta, Raul Muñoz, Ramon Casellas, Ricardo Martinez, Victor Lopez, Oscar González de Dios, Antonio Pastor, Georgios Katsikas, Felix Klaedtke, Paolo Monti, Alberto Mozo, Thomas Zinner, Harald Øverby, Sergio González, Håkon Lønsethagen, José-Miguel Pulido, Daniel King*

## **Workshop paper: “From 5G to 6G Automated and Intelligent Security: FAST. Cloud-Scale SDN Network Security in TeraFlow”**

*Alberto Mozo, Antonio Pastor, Carlos Natalino, Marija Furdek, Rahul Bobba, Raul Muñoz, Ramon Casellas, Ricardo Martinez ecomunicacions de Catalunya, Juan Pedro Fernández-Palacios, Ricard Vilalta, Stanislav Vakarak*

## **Special session paper: “Autonomous Network Management towards 6G. Cloud-Native SDN Network Management for Beyond 5G Networks with TeraFlow”**

*Ricard Vilalta, Raul Munoz, Ramon Casellas, Ricardo Martínez, Juan-Pedro Fernandez-Palacios, Georgios P. Katsikas, Thomas Zinner, Harald Øverby, Sergio Gonzalez-Diaz, Hakon Lønsethagenk, Jose-Miguel Pulido, Daniel King, Nicola Carapellese*

[Visit publication papers on TeraFlow website](#)

# Meet TeraFlow Partners

IN THIS SECTION WE WILL BE PRESENTING THE PARTNERS OF THE CONSORTIUM, THEIR PROFILE, MAIN EXPERTISE AND CONTRIBUTION TO THE PROJECT. IN OUR FIRST NEWSLETTER, YOU CAN KNOW MORE ABOUT CTTC, NEC AND UBITECH.



The Centre Tecnològic de Telecomunicacions de Catalunya (CTTC) is a non-profit research institution based in Castelldefels (Barcelona), resulting from a public initiative of the Regional Government of Catalonia (Generalitat de Catalunya). Research activities, both fundamental and applied, are organized onto four research divisions: Communication Networks, Communication Systems, Communication Technologies and Geomatics. CTTC has a strong track record of coordinating and leading EC-funded projects to success and aims to continue this tradition as the coordinator of TeraFlow and leader of WP1 ("Project Management"). CTTC is also responsible for the overall management and the interaction of partners, monitoring the progress of the technical outcomes and the accomplishment of the project milestones and related deliverables. CTTC is also responsible for (i) the TeraFlow OS integration, (ii) the transport network slicing infrastructure, and (iii) providing the suitable integration platform in WP5 for demonstrating the TeraFlow concepts. CTTC also will support communication and dissemination activities and 5GPPP collaboration in WP6.

CTTC researchers are perfectly suited for accomplishing these goals, leveraging the group's extensive experience in the development of novel networking paradigms and exploiting its world-class communication & networking laboratory infrastructure.



NEC Laboratories Europe is the European research center of the

NEC Group, a world leader in the computer and communications markets with a large world-wide base of R&D Laboratories. Top researchers from more than 20 countries develop, pilot, and bring to reality technologies through open innovation. NEC is convinced that distributed ledger technologies will play a dominant role in future IT systems, ranging from telecommunication networks over IoT and cloud platforms to financial services. In WP2 NEC will focus on security requirements and requirements for the distributed ledger component and will contribute to the general architecture and the APIs for interacting with the distributed ledger component. NEC is the leader of WP4 with the objectives of 1) designing and implementing an advanced cybersecurity solution, 2) designing and developing TeraFlow's permissioned blockchain and the dedicated smart contracts and 3) interworking across beyond 5G networks. Participants from NEC include Giorgia Marson and Rahul Bobba.



UBITECH is a leading, highly innovative software house, systems integrator and technology provider, established to provide

leading edge intelligent technical solutions and consulting services to businesses, organizations and government in order to allow the efficient and effective secure access and communication with various heterogeneous information resources and services, anytime and anywhere. UBITECH's R&D teams participate in large, multidisciplinary consortiums in complex and highly-innovative EU and international projects, spanning across the areas of cloud computing, software and services, programmable networking and 5G, digital security and privacy, big data, machine learning, analytics, etc. In the context of TeraFlow, UBITECH leads the research and development activities of WP3 "Life-cycle automation and high performance SDN components" as well as T3.3 "SDN Automation". Among the most prominent contributions in TeraFlow, UBITECH will design and implement (i) P4 drivers for the TeraFlow OS, (ii) high-performance flow processing mechanisms through smart hardware offloading, (iii) SDN automation mechanisms for next generation SDN devices (e.g., P4 switches) and/or Smart NICs, and (iv) transport network slices of different slicing technologies, which comply with network-level SLAs stemming from high-level service-level agreements (SLAs).



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