TeraFlow

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TeraFlow – Project Updates

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

Telefónica

We have succeeded in describing the necessary use cases for TeraFlow OS controller release 1. Several topics have been updated, including network automation, traffic engineering, compute integration and inter-domain connectivity services. Moreover, functional requirements have been updated to match the updated use cases.

The proposed architecture based on a micro-service architecture has been extended and each component is thoroughly detailed using a template that describes the main functionality, the proposed operations for the component, and the suggested internal data models. A protocol buffer is described for each of the components to model the services.

Moreover, within the T2.3 – *Business Model Analysis* – an analysis of TeraFlow OS ecosystem was carried out, foremost interviewing partners about ecosystem role, business model and expectations. In D2.1, first assessment of ecosystem structure and status, chain of cause-effect for growth, and long list of enabling and blocking mechanisms.

Finally, data models have been described, including external interfaces (northbound and southbound) and internal data models. Finally, sequence diagrams are presented to depict micro-service interactions. These include the following use cases: L3VPN Service Provisioning, Monitoring, Service Restauration, Traffic Engineering, Automation, Optical and L3 Centralized and Distributed attack detection, DLT and smart contracts, Compute integration and Inter-domain services.

WP3 – Life-cycle automation and high performance SDN components

UBITECH ubiquitous solutions

WP3 aims to design and implement the core components of the TeraFlow OS, touching upon important areas of modern network operating systems, including (i) scalable high-performance SDN control plane (T3.1), (ii) heterogeneous SDN hardware integration (T3.2), (iii) service and OS lifecycle automation (T3.3), and (iv) slice management (T3.4).

Between M6 and M12, the main objective of WP3 is to provide the design, interface specification, and preliminary evaluation of all core TeraFlow OS components in the context of D3.1.

Specifically:

- ☑ T3.1 provides five components:
  - the Context Management component which provides a solid API for TeraFlow to manage and store information related to devices, links, network topologies, and services.
  - the Monitoring component which offers means to subscribe to/ publish relevant monitoring metrics or composite key performance indicators related to lifecycle of microservices, the connectivity of network services/slices or network devices, and
  - the Traffic Engineering component which is responsible for setting up and optimizing segment routing paths in the infrastructure exposed by the device component.
  - the Auto Scaling and Load-Balancing components which leverage services by the Kubernetes Orchestrator to provide scaling and load-balancing services to TeraFlow.
- ☑ T3.2 provides two components:
  - the Device component which interacts with a variety of SDN devices. During M6-M12, the focus of this component was to manage 5 types of devices, including emulated software switches, optical

Transport API devices, ONF TR-532 microwave devices, NETCONF/ OpenConfig routers, and P4 whiteboxes.

* the Service component which is in charge of managing the life-cycle of the connectivity services established in the network. The current focus for this component is to develop an L3 VPN service using OpenConfig.T3.3 provides two components:

* the Automation component, also known as Zero-Touch Provisioning (ZTP) component, which consumes relevant network events to automatically trigger important network processes. The current focus for this component is to provide zero-touch device onboarding and configuration.

* the Policy Management component which offers an API for network operators to express high-level policies, both for specific devices but also for entire network segments, following the event-condition-action (ECA) policy model. The current focus for this component is to realize the ECA policy mode, which enables policy definition and enforcement.

- [x] T3.4 provides one component:

* the Slice Management component which ues the Network Slice Controller to realize a transport network slice, using physical and virtual network resources provided by the underlying network controllers. In the TeraFlow project, these controllers manage both optical and packet resource domains.

WP4 - Network security and interworking across B5G networks

NEC

The core objectives of WP4 target the design and the development of the TeraFlow OS components that are essential for network security. In addition, WP4 also has the objective of interfacing and integrating with other components in B5G networks. During the first year of the Teraflow project, WP4 has achieved the following outcomes and results

- [x] In T4.1, the centralized cybersecurity component has implemented its fundamental procedures. The preliminary performance and scalability results of the modules using a supervised and an unsupervised learning model have been published in two conference papers. The distributed cybersecurity component also implemented its fundamental procedures and the modules composing the components has been validated.

- [x] In T4.2, the Distributed Ledger Technology (DLT) component has been implemented based on the modular architecture of Hyperledger Fabric. In addition, a conference paper has been published presenting a Blockchain-based architecture to provide SDN actions to configure connectivity services in transport domains.

- [x] In T4.3, the Compute component which operates as a front-end for the NFV orchestrator has been implemented. Additionally, a blockchain has been used for the inter-domain management in which all the transport domains collaborate among themselves forming an end-to-end domain connectivity service.

WP5 – Prototype integration, demonstration and validation

CHALMERS UNIVERSITY OF TECHNOLOGY

In the second half of 2021, WP5 had several activities.

The project selected three scenarios representing some of the challenges posed by B5G networks, namely, Autonomous Network Beyond 5G, Automotive, and Cybersecurity. For each one of the scenarios, WP5 identified: the main technical challenges, the features required, the TeraFlow OS component to be developed to provide these features, and, finally, the use cases of interest to validate and benchmark the performance of the TeraFlow OS prototype. More details on the challenges, components, and use cases are available in D5.1.

In parallel with the scenario work, WP5 surveyed and evaluated options for the qualification platform to be used in the project. The final choice went for GitLab CI/CD because it offers (among other features) source code management, version control, and code documentation in a single application.

WP5 also defined the reference architecture for the TeraFlow OS components under development. This general architecture is detailed in D5.1, where the folder and files available within the TeraFlow OS source code folder are described. WP5 also looked into the methodology to develop, integrate, test, and release the artifacts produced by TeraFlow. The proposed method comprises four complementary tiers: functional architecture and pipeline, TeraFlow CI/CD infrastructure, good practice and hints for CI/CD usage, and release time plan. This methodology is described in D5.1 At the end the deliverable instructions on where and how to install the TeraFlow OS prototype are also provided.

WP6 – Standardization, Dissemination and Exploitation

Atos

To maximise the value of the project results, WP6 defines, supports and monitors an impact creation strategy that covers all the tasks and activities of WP6.

In this second part of the year, from July until December 2021, we have been continuously producing relevant content and delivering it to external audiences for keeping them engaged and aware of our activities. Our social media channels count already with 164 followers on Twitter and 69 followers on LinkedIn and we are proud to achieve more and more interactions every day.

Generating impact and disseminating the project's findings and results among research and academic communities has been mainly done through the active development of papers and its posterior presentation and publication at important conferences (ONDM 2021, OMNET++ Community Summit, PSC 2021, ECOC 2021, CNSM 2021, NetCentric 2021, NoF 2021, IEEE NFV-SDN 2021, NGON DCI 2021) and journals (IEEE networks, MDPI Photonics). TeraFlow has also participated in external events and has organised own events/workshops in collaboration with other initiatives and projects (OSM ecosystem day or 5G PPP webinars, for example) or co-located within bigger and renowned venues (like MWC 21), reaching over 3000 persons of different role and background such as researchers, academics, industry and standardisation bodies.

TeraFlow has continued closely monitoring standardization activities and fostering collaboration with standardisation bodies to assist with forming strategies and ensure that TeraFlow objectives are met. As such, TeraFlow is taking part in relevant working groups (in ETSI, ITU, ONF, OpenConfig, IETF and TIP), and other industry fora. Besides, TeraFlow partners recognise open-source communities as important

pillars to ensure the sustainability of the project results and uptake by third parties and, in fact, the key objective of the project is to design and develop a new generation SDN controller and contribute with it back to the community. Currently, TeraFlow involved partners are closely discussing with OSM developers to accomplish a functional integration between OSM latest release and the TeraFlow OS architecture. Also, TeraFlow is exploiting relevant channels in ONF and HyperLedger so that their users can leverage TeraFlow for research and innovation activities.

In coordination with WP2 activities on stakeholders and ecosystems, WP6 exploitation activities have analysed TeraFlow main target, the network operator, as well as other actors needed for TeraFlow ecosystem to flourish, their motivation and the interactions among them. The environment analysis conducted in this period of time has highlighted the factors that can influence, positively or negatively, the success of our project and has allowed to build on TeraFlow OS added value steaming from the market analysis and competitors: to enable network programmability in vendor agnostic transport networks in the new 5G use cases proposed. In light of these findings, partners of the Consortium, with different profiles and expertise, are reflecting on the business opportunities they identify as a result of their participation in TeraFlow project.

Latest deliverables submitted

D2.1 - Preliminary requirements, architecture design, business models and data models. ➔

D3.1 - Preliminary evaluation of Life-cycle automation and high performance SDN components. ➔

D4.1 - Preliminary evaluation of TeraFlow security and B5G network integration. ➔

D5.1 - Testbed setup and prototype integration report. ➔

D6.2 - Market and business opportunities analysis and intermediate report on Dissemination, Communication, Collaboration and Standardisation. ➔

Highlights of the period

First Advisory Board Meeting

17 December 2021

TeraFlow celebrated the 1st virtual meeting with the Advisory Board with the aim to present the impact and the main achievements of each one of the Work Packages on the first year of funding. Also, the motivation behind the creation of a novel cloud-native SDN controller was introduced along with the three scenarios where the TeraFlow OS components will be validated.

The members gave very positive feedback and some guidance for future work on how to ensure the sustainability of the TeraFlow SDN controller after the H2020 TeraFlow project ends. This future effort aims to maintain the momentum of the standardisation efforts, seek touchpoints with ETSI, and study the possibility of performing a PoC (Proof of Concept).

Meet our Advisory Board

Silvia Almagia

Silvia is Technical Expert within ETSI's Centre for Testing and Interoperability. Her current activities include providing technical management and testing expertise in the areas of open source, interoperability testing, and proofs of concept (PoCs). Among others, she is in charge of the Open-Source MANO project (ETSI OSM), the NFV&MEC Plugtests program, and several PoC Frameworks.

Prior to this position, Silvia was Lead Member of the Technical Staff at Ulticom, where she was responsible for the design and development of software-based carrier grade solutions enabling mobile services. Before that, she worked in the domain of Operations Support Systems (OSS) and Network Management for HP and Thales.

Noboru Yoshikane

Dr. Noboru Yoshikane is currently a senior manager in the photonic transport network laboratory, KDDI Research, Inc., Japan. He has been engaged in various R&D topics including development of international submarine cable systems, terrestrial optical transport network systems, network control and management techniques, software-defined networking, and space division multiplexing technology. He has been working on national and international projects regarding optical networking technologies. He has served a TPC chair/member for international conferences (OFC, ONDM, OECC, etc.).

Diego Mari

Diego Marí Moretón is Connectivity Technologies & Ecosystems Manager at Meta, working with Service and Technology providers to develop the next generation of IP and Optical solutions that will connect more people to a faster internet. He is leading TIP Open Optical Packet Transport Project Group (OOPT) and previously worked as IP Product Manager at Huawei Technologies and as IP & SDN Network Architect at Vodafone.

News & Events

Public Side Meetings at IETF-111

28 Jul 2021 | VIRTUAL

TeraFlow participated at the "Evolving and Revitalizing the Internet" side-meeting co-located within the IETF-111.

The Internet Engineering Task Force (IETF) is a large open international community of network designers, operators, vendors, and researchers concerned with the evolution of Internet architecture and the smooth operation of the Internet.

IETF participants occasionally organize side meetings to discuss topics of interest to some portion of the IETF community. In this case, Adrian Farrel from Old Dog Consulting and a member of TeraFlow Consortium hosted and moderated the 90-minute meeting. ➔

OMNeT++ Community Summit 2021

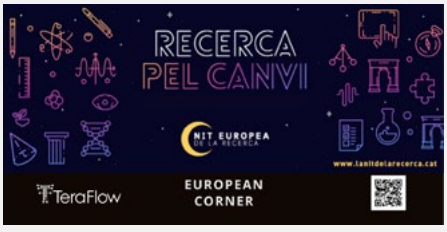
08 Sep 2021 | Virtual

OMNeT++ is a public-source, component-based, modular and open-architecture simulation environment with strong GUI support and an embeddable simulation kernel. It is designed to simulate discrete event systems, with the simulation of communication networks as one of its primary application areas. ➔

Photonics in Switching and Computing 2021

29 Sep 2021 | Virtual

Photonics in Switching and Computing highlights the latest research activities in areas related to "Photonics in Switching" and to "Photonics in Computing".is year's conference will highlight the synergy between photonic technologies, systems and computing/networking architectures. ➔



Nit Europea de la Recerca

21 Sep 2021 | Virtual + Barcelona, Spain

The European Research Night is a public event dedicated to the dissemination of science. Its aim is to bring research, innovation and its protagonists to the public of all ages in a smooth and fun way.

This event is held every year in more than 300 cities in 30 European countries at the same time. In the previous edition, more than 200 activities were carried out in Catalonia, including talks, workshops, experiments, shows and games. ➔

Net-Centric 2021 Conference

30 Sep 2021 | Virtual

This conference is expected to reach new heights in addressing contemporary topics of interest to the industry. Building upon the success of its predecessors will continue to offer great insight into emerging solutions and technologies that promises to shape the next generation networks.

The event will cover interesting areas of Big Data & Self-Learning Networks, Cloud Networks and Data Centers, Virtualization, Network Analytics, Security Monitoring and Forensic Analysis, Networking and Computing Infrastructure Management, Software Defined Networks (SDN), and Open Source- Software and Technologies.➔

12th International Conference on Network of the Future (NoF 2021)

07 Oct 2021 | Coimbra, Portugal (Virtual Conference)

NoF is a premier annual conference that covers advances in the area of Future Internet design, with emphasis on enabling technologies, architectures, and services. ➔

TIP OOPT MUST | H2 2021 Public Webinar

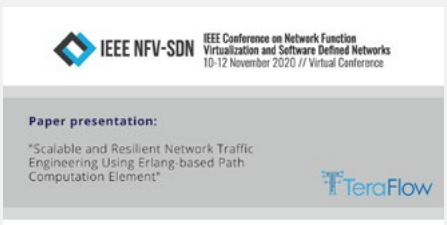
27 Oct 2021 | Virtual

Join TIP's Open Optical Packet Transport for a webinar sharing the latest news and developments from the MUST project sub-group. MUST, Mandatory Use Case Requirements for SDN Transport, is a new program within OOPT to define a common SDN architecture and open and standard interfaces between the control and management layer to fulfill operators' needs. MUST deliver requirement documents operators can use as part of the RFI, RFP, and RFQ processes to ensure their solutions provide open and standard-based interfaces. ➔

17th International Conference on Network and Service Management

26 Oct 2021 | Izmir, Turkey | Virtual

CNSM is a premier venue for the presentation of novel results and ongoing reports in all aspects of the management of networks and services. The conference offers an engaging program that starts with one timely workshop and four mini-conference sessions on the first day, followed by three days of a single track consisting of keynotes, technical paper sessions, poster and demo sessions, and a panel of distinguished experts. The last day of the conference ends with one workshop and two tutorials. ➔



IEEE Conference on Network Function Virtualization and Software Defined Networks

10 Nov 2021 | Virtual Conference

Network Functions Virtualization (NFV) and Software Defined Networks (SDN) are an accepted evolution in all areas of network concepts and technologies. They are dramatically transforming telecommunication networks, campus, enterprise, and data center networks, and accelerating the introduction of technologies and applications, which enable programmatic control of networks. Currently, NFV and SDN are in the transition phase from development and trials to full-scale deployments. ➔

NGON & DCI World 2021

19 Nov 2021 | Virtual

NGON addresses optical innovation and drive towards Terabit transmission with a smarter and more flexible exhibition and conference.

Within the event, TeraFlow held the workshop “TeraFlow: Utilizing Optical Network Slicing to Connect Clouds for Autonomic 5G and Beyond Services”. See the recording of the workshop and presentations at NGON & DCI World 2021. ➔

Next Events

ICT-52 Workshop on 6G

03 Feb 2022

The workshop is organised by Hexa-X, the European 6G Flagship project, together with other 6G projects belonging to the 5G PPP – Smart Connectivity beyond 5G (ICT-52), which have the common challenge to go well beyond the 5G capabilities developed under 3G PPPP release 16 while also advancing on the development of Smart Connectivity systems as a platform for a Next-Generation Internet to support highly flexible connectivity infrastructure. ➔

OFC Conference 2022

06 March 2022 | San Diego, California, US

OFC is the largest global conference and exhibition for optical communications and networking professionals. The program is comprehensive -- from research to marketplace, from components to systems and networks and from technical sessions to the exhibition. For over 40 years, OFC has drawn attendees from all corners of the globe to meet and greet, teach and learn, make connections and move the industry forward.

TeraFlow will participate on this year's edition with the presentation of three papers and a demo titled "Demonstration of Zero-touch Device and L3-VPN Service Management using the TeraFlow Cloud-native SDN Controller". ➔

Papers

Scalable Physical Layer Security Components for Microservice-Based Optical SDN Controllers

Natalino, Carlos, Manso, Carlos, Vilalta, Ricard, Monti, Paolo, Munoz, Raul, Furdek, Marija ➔

Field Trial of Programmable L3 VPN Service Deployment Using SDN-Based Multi-domain Service Provisioning over IP/Optical Networks

Samier Barguil, Victor Lopez, Cristyan Manta-Caro, Arturo Mayoral Lopez De Lerma, Oscar Gonzalez De Dios, Edward Echeverry, Juan Pedro Fernandez-Palacios, Janne Karvonen, Jutta Kemppainen, Natalia Maya, Ricard Vilalta ➔

Optical Network Telemetry with Streaming Mechanisms using Transport API and Kafka

Ricard Vilalta, Ramon Casellas, Ricardo Martinez, Raul Muñoz, Alfredo González-Muñiz, Juan Pedro Fernández-Palacios ➔

First Demonstration of Dynamic Deployment of SDN-enabled WDM Virtual Network Topologies (VNTs) over SDM networks

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

Packet Optical Transport Network Slicing with Hard and Soft Isolation

Samier Barguil , Victor Lopez Alvarez , Luis Miguel Contreras Murillo , Oscar Gonzalez de Dios , Alejandro Alcala Alvarez , Carlos Manso, Pol Alemany, Ramon Casellas , Ricardo Martinez, David Gonzalez-Perez, Xufeng Liu , Jose-Miguel Pulido , Juan Pedro Fernandez-Palacios , Raul Muñoz, Ricard Vilalta ➔

Role of monitoring and analytics in next-generation optical networks

Lluis Gifre Renom, Fabien Boitier ➔

HTBQueue: A Hierarchical Token Bucket Implementation for the OMNeT++/INET Framework

Marcin Bosk, Marija Gajic, Susanna Schwarzmann, Stanislav Lange, Thomas Zinner ➔

SDN Control Architectures for WDM over SDM (WDMoSDM) Networks

R. Muñoz, N. Yoshikane, C. Manso, R. Casellas, R. Vilalta, R. Martínez, F. Balasis, C. Wang, T. Tsuritani, I. Morita ➔

Using 5G QoS Mechanisms to Achieve QoE-Aware Resource Allocation

Marcin Bosk, Marija Gajić, Susanna Schwarzmann, Stanislav Lange, Riccardo Trivisonno, Clarissa Cassales Marquezan, Thomas Zinner ➔

Demo paper: Scalable and Resilient Network Traffic Engineering Using Erlang-based Path Computation Element

Sebastien Merle, Juan Pedro Fernández-Palacios, Oscar González de Dios, Lluís Gifre, Ricard Vilalta, Peer Stritzinger ➔

Meet the partners

IN THIS SECTION WE WILL BE PRSENTING THE PARTNERS OF THE CONSORTIUM, THEIR PROFILE, MAIN EXPERTISE AND CONTRIBUTION TO THE PROJECT. IN OUR SECOND NEWSLETTER YOU CAN KNOW MORE ABOUT CHALMERS. SEE THE REST OF THE PARTNERS HERE:

CHALMERS UNIVERSITY OF TECHNOLOGY

Chalmers University of Technology in Gothenburg was founded in 1829 and has about 10,000 students and 3,000 employees. It is the most reputable university in Sweden, consistently ranking as number one in public perception surveys. Chalmers participates in TeraFlow with the Optical Networks (ON) group, headed by Prof. Paolo Monti, at the Department of Electrical Engineering. The group researches network architecture design and optimization, control and management, fibre access and mobile transport networks, network sustainability, reliability, security, and survivability. The group is a part of the Fiber-Optic Communications Research Center of Excellence (FORCE), bringing together cross-disciplinary research in communications, photonics, electronics. The ON group is also active in the Chalmers AI Research Centre (CHAIR), founded to develop unique AI expertise in research, education, and innovation. CHAIR offers a highly attractive environment for world-leading AI researchers and has become the preferred AI partner for the Swedish industry. The work of the ON group is tightly connected to Swedish and European industries.

Chalmers participates in WP2 where it leads T2.1 and it also contributes to the definition of the TeraFlow OS architecture and data model. The team is involved in WP3 to implement orchestration methods for traffic steering and failure/ attack recovery. Moreover, participates in WP4 where it develops techniques for identifying and mitigating cybersecurity threats. Chalmers leads the activities in WP5 and T5.3, where it is involved in the integration and demonstration efforts related to the cybersecurity use case. Finally, they participate in the dissemination activities of WP6.

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