Metro-Haul

METRO High bandwidth, 5G Application-aware optical network, with edge storage, compute and low latency

Grant No. 761727

METRO-HAUL Second-year Innovation: Partners contribution.

Relevant topics:

- ***What Metro-Haul project has done that is really new***
- ***What are the compelling use cases for each innovation***
- ***Has some IPR been filed per each innovation?***
- ***Could some official events or similar (e.g. participation at OFC exposition or new product announcements) be connected with partner Metro-Haul innovation in some way?***

Synoptic Table of Metro-Haul concrete innovation is included

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1 Rationale

The document reports the current innovation developed during the Metro-Haul project, and to be included in the second-year periodic report.

In summary, the overall trend is positive; the project also gained a number of new innovative activities.

Noteworthy is the generation of two IPR one filed and the other still pending which strengthen Metro- Haul innovation.

The document structure first introduces the basic concepts and guidelines of innovation pursued in Metro-Haul, then details each innovation qualifying point.

2 Introduction

The Innovation Management activity in the second year of the project activity focused on analysing the areas of METRO-HAUL project that provide commercial opportunities for innovation and fruitful exploitation in terms of novelty, inventiveness and intellectual property protection opportunities. Project commercial partners, SMEs as well as large companies, based on different perspectives, are aiming to enhance their product portfolio and reuse the enabling techniques and technologies developed within the project.

All partners involved are starting to implement some initial ideas for innovation impact in the Metro-Haul project. We have collated this information and shared our initial findings via the internal file repository: https://bscw.metro-haul.eu, specifically in the relevant folder Task 6.2. Innovation Management is still defined as “work in progress” and is continuously updated as the project develops. Innovation developments are typically documented in both internal and external reports and harmonised in support of a functional vision for innovation in the project.

While expressing their innovation impact, the involved partners were asked to comment on three innovation survey questions documented below:

- Clarify key Metro-Haul project developments and innovations;
- What are the compelling use cases for identified innovation?
- Declare if and what IPR has been filed per innovation, and per partner.

Significantly, the innovation results emerged thus far and disclosed during the survey, are extremely compelling and demonstrate an auspicious trend for the project. The highlights of this report reflect the joint work on how the technological transformation of optical networks can enable emerging 5G applications to the advantage of operators and their customers, these are key objectives documented when the project was originally proposed.

For each innovation implemented in Metro-Haul, we will report innovation and novel developments, combined with the use cases and partner plans for intellectual property protection.

3 Progress during the Second Year period of Metro-Haul

Since the project started in May 2018, the evidence and the importance of collaboration of industry with academia, between operators and equipment manufacturers, and network operators have been continuously stressed as essential objectives.

During the first year, a clear separation was established to highlight innovative research, and what represented commercial innovation activity and innovation opportunities, across all WPs of Metro-Haul.

During the second year, two principal attitudes have been used by project partners when discussing and documenting innovation in the project, specifically: ingenuity and creativity.

- **Ingenuity** is here intended as the attitude to give a correct answer to a well-posed question or, more specifically, to find a solution to a new technological problem and facilitate its evolution;
- **Creativity** is intended as the attitude to give a useful answer to a question which has not been well-posed yet or, more specifically, to find innovative approaches where technical issues are not well-defined as yet

Ingenuity, in the context of this document, is applied for the short and medium-term time horizon, creativity for the long term innovation. Ingenuity led to solving all implementation issues coming with the upgrade of the current state of the art of telecommunication networks toward 5G evolution; enabled by new technological instances mainly based on the use of flexible optics and the concept of network function component disaggregation.

Creativity is used to propose an alternative scenario to overcome the existing technological limits of energy and cost efficiency in the installation of new feature-rich optical networks serving an undetermined number of new services, paving the way for capabilities and services not yet invented.

The principal technological approaches utilise two guiding principles: improving both the fast responsiveness and the transparency of the network; furthermore, we are ensuring economic costs are sustainable and minimising power consumption where possible:

- the design and the deployment of alternative network architectures deeply analysed in Metro-Haul and now under discussion in international fora and symposia;

- the definition of those new devices and apparatus realisations (e.g. exploiting the silicon and III-V based photonics).

Fast responsiveness, is the potential to reduce the latency of information in a network, allowing for the broadband transmission (e.g. 100 Gb/s and beyond) and the short-time commutation (e.g., microseconds instead of milliseconds or more) of the network interconnections.

Transparency is used to define the potential of agile and flexible deployment of the network service leveraging on virtual and software-based infrastructure.

The infrastructure is based on innovative, proprietary and customised hardware but utilising standard interfaces which may be easily exploited in a large-scale and multi-domain infrastructure with geographically distributed and interconnected Datacom and Telecom networks.

4 Innovation Contributions from Project Partners

In this section we report the survey and interview results and document the critical project innovations, which include: frameworks, processes, and technologies, which have been identified by Metro-Haul commercial and academic partners.

Each innovation states the novelty, the use cases and the potential intellectual property rights. A synoptic table, Table 1, is here reported to recap Metro-Haul innovation and clarify what is new.

Where appropriate, patent filings have begun for significant project technology developments, especially related to algorithms and hardware developed by Metro-Haul partners. In some cases international patent filings have begun, or patent applications are currently pending. In critical examples, some inventive ideas and patents have been provided to project partners with fair, reasonable, and non-discriminatory (FRAND) terms.

Innovative project software, created and used in Metro-Haul for several innovations, has also been made available within the project partner consortium as “open software”, and in most of the cases loaded in specialised hardware and shared in several demonstrators.

The expected outcome in a medium/long term is to provide new skills, knowledge and technological solutions to reduce OPEX and CAPEX in metro networks, to enhance efficiency and speed in service activation and to foster efficient integrated network storage and computing solutions. These concepts may be further developed into education material such as tutorials, webinars and whitepapers.

A Synoptic Table of Metro-Haul Innovations is provided in the table on the following page.

Paragr.	Innovation	Partners	Novelty in Metro-Haul
4.1	Hierarchical SDN control system for Multilayer Disaggregated Networks	CTTC, CNIT, TID	SDN system incorporating service and device models
4.2	SDN Controller for Passive Optical Networks	OLC	Seamless SDN integration of deployed PONs by standardised protocols
4.3	NETCONF Agents for Optical Devices	CNIT and TIM	Optical controller of real device also emulating capabilities
4.4	ETSI MANO System Encompassing Transport Networks	UNIVBRIS, CTTC, TID	OSM extension for network service multiple PoPs with external WIM
4.5	System for Network Virtualization and Slicing	UNIVBRIS, CTTC, TID	Using OSM with "ETSI MANO System" featured by UNIVBRIS
4.6	Monitoring and Data Analytics (MDA) Subsystem	UPC	CASTOR MDA system extension to fit multilayer metro networks
4.7	Network Planning and Monitoring Subsystem	UPCT and POLIMI	New Java libraries have been developed and dissemainated
4.8	Network Monitoring Probes at 100 Gb/s	NAUDIT	Brand-new network probes at 100Gbit/s
4.9	Service and Traffic Monitoring System	NAUDIT	High-speed network monitoring system at 100 Gbit/s
4.10	VNF Placement Algorithms	POLIMI	Activity originated within Metro-Haul
4.11	System for Autonomic Optical Channel Provisioning **(Patent filed)**	Infinera Portugal	In-house concept development for QoT use-cases
4.12	Configurable and Disaggregated Metro Network Design and Deployment	Infinera Portugal	Hardware and software development performed in-house independently of Metro-Haul
4.13	SDN Application for managing spectrum fragmentation in a multilayer optical network	Nokia IT (NSN)	Reconfigure over established channel high priority services by OTN
4.14	Low-cost Low-energy Metro Transponders with Low-resolution DAC and/or ADCs	NBLF	Compelling new idea started within METRO-HAUL project
4.15	Automated Network with Monitoring and Machine Learning	NBLF	Extend monitoring and real-time capabilities to predict BER
4.16	SDN application for proactive soft-failure detection	ADVA and HHI	Novel data-driven approach to failure mode analysis
4.17	Demonstration of Multi-domain, Multi-layer Network for Support of Sliceable Wholesale Services for Mobile Network Operators	ADVA and BT	New edge computing for the 5G transport and orchestration of different networks
4.18	Silicon Photonics Modulator for Coherent Transceiver	ADVA	New designs of a SiPh modulator for coherent transmission
4.19	SDN-Enabled Flexi-grid Optical Domain Controller based on NETCONF/YANG	ADVA	New optical domain controller in ADVA's commercial system
4.20	NETCONF-based Low Latency Cross-connect for 5G C-RAN Architectures	ADVA	Cross-connect in SDN control and NETCONF-based SBI controller
4.21	Integrated Photonics White Box	TEI and CNIT	Use of silicon photonics switch (IRIS) in a Whitebox
4.22	Agent for an Integrated Photonics White Box	TEI and CNIT	Originated within Metro-Haul
4.23	Integrated Photonics Tunable Optical Dispersion Compensator	TEI and CNIT	Activity that originated with Metro-Haul
4.24	Agent for an Integrated Photonics Tunable Optical Dispersion Compensator	TEI and CNIT	Activity that originated with Metro-Haul
4.25	Video Surveillance on the network edge	Qognify (Seetec)	Law latency in tracking-camera remote operation (pan tilt zoom)
4.26	Licensing of IP **(Patent Pending)**	HHI	Novel perturbation-based fibre-nonlinearity compensation
4.27	5G Berlin Innovation Cluster	HHI	Public safety by intelligent video analytics demonstrator
4.28	Orchestrating 5G services over dis-aggregated Metro-Haul Network	Zeetta	SDN controller architecture and orchestration for video streaming
4.29	Applications of Machine Learning algorithms in optical networks	UC3M, POLIMI, TID	Activity that originated with Metro-Haul
4.30	Guidelines for rethinking the architecture of Central Offices applying disaggregation and softwarization paradigms	TIM, BT and TID	Emulated OpenROADM and OpenConfig by "Docker containers"
4.31	A multi-purpose loss-less photonic integrated wavelength selective switch	TU/e	The innovation is entirely an activity that originated with Metro-Haul

Table 1 Synoptic Table of Metro-Haul Innovation

4.1 Innovation from CTTC, CNIT and TID: Hierarchical SDN control system for Multilayer Disaggregated Networks

The innovation by CTTC, CNIT and TID is in the definition of a hierarchical SDN controller, extending the open-source ONOS framework and using standard interfaces and model-driven development. The controllers will manage devices that are using either OpenConfig or OpenROADM resource models, additional devices may also be controlled if their YANG data model is made available. The SBI is based on NETCONF, and the NBI will be using TAPI 2.2, including connectivity and topology models. SDN controller for the parent orchestrator will be responsible for the end-to-end service provisioning.

4.1.1 Novelty in Metro-Haul

Metro-haul has designed and implemented a hierarchical SDN system that incorporates, for the first time, state of the art service and device models, including:

- TAPI 2.1 Service model including new releases covering the Photonic Layer
- OpenConfig Optical Terminal devices
- OpenROADM v2.2 devices
- Extended Lumentum ROADM-20 drivers

Metro-Haul has established a liaison with the ONF ODTN project. The SDN controller interacts with a planning tool and a Machine and Data Analytics subsystems, leveraging advanced monitoring and telemetry such as advanced transceivers.

4.1.2 Use Cases

The use cases identified so far are the following:

- SDN control of disaggregated optical networks, supporting multiple levels of disaggregation such as partial and full
- SDN control of optical devices following open, standard and agreed-upon device data models
- SDN control of multilayer and multi-domain networks
- Advanced telemetry and monitoring in support for SDN-based network operation

4.1.3 Intellectual Property Rights

Currently, no IPR has been formally filed but the source code has been published as Open Source in the Upstream project ONOS SDN Controller: https://www.opennetworking.org/news-and-events/blog/community-members-spotlight-ramon-casellas-and-alessio-giorgetti/

4.2 Innovation from OLC: SDN Controller for Passive Optical Networks

SDN architecture for enabling an SDN-compatible control-plane of commercially deployed PONs using standard protocols, without introducing new extensions, to avoid deployment complications. The main building blocks of the platform are ConfD tool, the PON Configuration Agent (PCA), the PON Network Flow Agent (PNFA) and the PON Controller.

4.2.1 Novelty in Metro-Haul

The PON Configuration Agent (PCA) and the PON Controller have been entirely developed within Metro-Haul. An earlier standalone version of the PON Network Flow Agent (PNFA) was available at the start of the project, but this has also been modified to work within the overall architecture, abstracting the legacy PON as a fully SDN controlled switch. This abstraction a) hides the PON specific details of forwarding and control/management operation, while b) vendor-specific configuration commands are automatically translated and executed. All is done while employing standardised SDN protocols.

4.2.2 Use Cases

There is currently a huge amount of Passive Optical Network equipment installed in operator's networks, comprising systems purchased from different vendors. Any overall SDN control solution must be interoperable with such currently installed solutions. The developed SDN-compatible controller allows the seamless SDN integration of commercially deployed PONs using standardised protocols without modifying the already deployed control/management tools. Moreover, this approach allows capitalising on the increased penetration of SDN in other network segments (WAN/Metro).

4.2.3 Intellectual property rights

No IPR has been filed so far.

4.3 Innovation from CNIT and TIM: NETCONF Agents for Optical Devices

A NETCONF server implementing OpenConfig and OpenROADM YANG models will be therefore implemented and deployed for each optical device considered in the METRO-HAUL architecture. In metro optical transport networks, disaggregation is considered an exciting paradigm to save costs, reduce vendor lock-in and allow a faster and dynamical pace of innovation introduction.

4.3.1 Novelty in Metro-Haul

This activity has been funded almost entirely by METRO-HAUL. We consider this a significant innovation step in checking disaggregation scenarios as it is allowing us to control real device and create a lot of emulated ones to test optical controller capabilities.

4.3.2 Use Cases

Up to now, the ecosystem is still in an infancy stage, far from being mature for large scale deployment in TELCO networks. In particular, although some open community, especially OpenROADM, has already specified in detail vertical and horizontal optical interoperability for ROADM and transport optical analogue network elements, no, or very few, commercial (or even prototypal) optical white boxes are present on the market to test feasibility and pros/contra of optical disaggregation.

To partially fill this gap, TIM decided to invest in the development of an OpenROADM NETCONF agent software sufficiently "open" and "generic" to enhance existing devices (e. g. from Lumentum) and

ROADM prototypes developed by TIM and other METRO-HAUL partners, turning them OpenROADM white boxes.

4.3.3 Intellectual property rights

No IPR has been filled as this agent have been designed to be "open software" within METRO-HAUL to foster enhancing of the number of OpenROADM compliant prototypes. At the end of the project, we are considering a possible public release of the software to help the open community in developing emulated testing devices.

4.4 Innovation from UNIVBRIS, CTTC and TID: ETSI MANO System Encompassing Transport Networks

Management and Network Orchestration of Virtualized Network Services running over NFVI (OpenStack) with an integrated WIM component and a WIM SDN Controller to create L2 network slicing over the WAN Infrastructure.

4.4.1 Novelty in Metro-Haul

The novelty in Metro-Haul is in extending OSM to deploy a network service spanning multiple PoPs (datacenters) using an external WAN Infrastructure Manager (WIM). This part is reported in OSM release 5 and was not included in previous OSM releases. This feature allows L2 network slicing over the WAN infrastructure inter-connecting multiple PoPs.

4.4.2 Use Cases

The reported innovation allows a network service spanning multiple datacenters, enabling compelling use cases. One of the use-cases utilising this feature is the Metro-Haul Crowdsourced video use-case to be shown in Bristol, the United Kingdom as a verification of the project. The use-case utilises crowdsourced videos to be streamed back to a user from, e.g. a stadium, where VNFs hosted at various PoPs in a metro network process and filter the video streams.

4.4.3 Intellectual property rights

No patents filed, however open source contribution to OSM release 5 [OSM] has been done along with publications [Bravalheri], [Diallo] and demos [EuCNC'19], [Hackfest'19].

4.5 Innovation from UNIVBRIS, CTTC and TID: System for Network Virtualization and Slicing

The innovation consists of an integrated environment for VNF deployment across data-centres using single or multiple OSM instances. The OSM must orchestrate network functions and create a service chain between them automatically using the ETSI NFV descriptors. Non-interfering co-existence of multiple network service chains between the two of more data-centres would reflect the network slicing capabilities.

4.5.1 Novelty in Metro-Haul

Using OSM with "ETSI MANO System" featured by UNIVBRIS to deploy a network service spanning multiple PoPs (datacenters) using an external WAN Infrastructure Manager (WIM), layer 2 networks at each datacenter can be interconnected by an external WIM which may use an intermediate VLAN over the transport network, enabling end-to-end network slicing.

4.5.2 Use Cases

The compelling use case is a network service spanning multiple datacenters. The use-case can utilise crowdsourced videos to be streamed back to a user from, e.g. a stadium, where VNFs hosted at various PoPs in a metro network process and filter the video streams.

4.5.3 Intellectual property rights

No patents filed, however open source contribution to OSM release 5 [OSM] has been done along with publications [Bravalheri], [Diallo] and demos [EuCNC'19], [Hackfest'19]

4.6 Innovation from UPC: Monitoring and Data Analytics (MDA) Subsystem

The MDA subsystem includes MDA agents running close to the network nodes, and a big data centralised MDA controller running in the control and management plane. Agents collect monitoring data, which can be used for knowledge discovery to implement local control loops proactively. The controller collates measurements and stores them in a (big data) repository.

4.6.1 Novelty in Metro-Haul

The novelty in Metro-Haul is in extending UPC's CASTOR MDA system to fit the characteristics of multilayer metro networks. This includes the implementation of a number of interfaces and APIs to communicate CASTOR MDA with the rest of the systems in the Metro-Haul's Control, Orchestration and Management architecture, interfaces for collecting monitoring and telemetry, as well as the development of specific machine learning based algorithms for autonomic transmission and networking.

4.6.2 Use Cases

Several use cases are targeted. 1) Autonomic tuning of soft-FEC iterations based on predicted number of bit errors; 2) Autonomic reconfiguration after degradation detection and soft-failure identification and localization; 3) Autonomic adaptation of the virtual network topology based on traffic prediction; 4) support for autonomic network services. Some of these use cases have been demonstrated in international conferences, like ECOC and OFC.

4.6.3 Intellectual property rights

No IPR has been filed so far.

4.7 Innovation from UPCT and POLIMI: Network Planning and Monitoring Subsystem

The open-source Java-based Net2Plan tool has been chosen as the planning tool / Back-end for placement, planning and reconfiguration of VNFs, IT and network resources. This including off-line algorithms for traffic-based dynamic metro resource activation, with the correlation of service traffic monitoring, resource availability and service requirements. Net2Plan runs multiple algorithms including VNF Placement and Scaling Optimizer (NPSO) and Network Resource Allocation Optimizer (NRAO).

4.7.1 Novelty in Metro-Haul

Metro-Haul approach is leading a paradigm based on the joint planning and optimization of both the IT and multilayer (optical and IP) network resources in the network. In this respect, a Java Library called NIW (NFV over IP over WDM) has been developed by UPCT, and is openly

disseminated, to facilitate together with Net2Plan software, the development of joint optimization and planning schemes. In addition, libraries have been developed for connecting Net2Plan to OSM (Open Source MANO), OpenStack and ONOS Controller in different forms. Several demos and Proof-of-Concepts has been shown in forums like OFC 2018 and 2019, ECOC 2018 and 2019 and EUCnC 2019.

4.7.2 Use Cases

Network planning subsystem in all the use cases developed in MetroHaul. Its role is: (i) online optimization for allocation of IT and network resources, (ii) offline capacity planning and topolgy design.

4.7.3 Intellectual property rights

No IPR has been filled. Note that the approach of choice for this innovation is not based on IPR protection, but on disseminating the software and related material publicly, using open licenses like MIT License, or Apache-like licenses, promoting a community build-up around the solution, that can be the base of further added-value services.

4.8 Innovation from NAUDIT: Network Monitoring Probes at 100 Gb/s

Network backbones will be running at 100+ Gbit/s, and Naudit's clients will be demanding more and more information about network behaviour. In this context, the development of new active and passive network probes is a must. However, it is going to be extremely difficult to implement Naudit's future monitoring probes using just commodity servers, and a mixed approach with FPGA developments is foreseen.

4.8.1 Novelty in Metro-Haul

When the Metro-Haul project started, Naudit did not have in its portfolio any network probe nor monitoring solution working at 100Gbit/s, and this has been our main innovation to accomplish within the scope of the project. Naudit is not involved in any other externally funded project with this objective. The experience gained from Metro-Haul is being precious for Naudit to provide better network monitoring services at a better cost and is helping us to tackle with the incoming demands of our clients, requesting network probes and monitoring systems able to work at 100Gbit/s.

4.8.2 Use Cases

In the following years, at Naudit, radical changes are expected in the network monitoring business. Network backbones will be running at 100+ Gbit/s, and our clients will be demanding more and more information about the network behaviour. In this context, the development of new active and passive network probes and monitoring systems working at 100 Gbit/s is a must. For instance, regarding the scope of the ICT-07-2017 topic, an essential result of Metro-Haul that we will like to exploit is the monitoring of future 5G metro networks. Thus, we are evolving our network probes and monitoring systems so we can work at 100 Gbit/s, primarily oriented in the 5G context, where high bandwidth and ultra-low latency services are going to be provided. Such services have to be accurately measured, and this is the main challenge we are focusing right now. It is also clear that these developments will be precious in other deployments as well, such as data centre networks.

4.8.3 Intellectual property rights

Given that Naudit development is mainly based on software that is loaded in specialised hardware

from third parties, we do not currently have plans to fill any patent, given that software patents are not allowed in Europe. We will use another type of IPR, such as software licenses and industrial secrecy.

4.9 Innovation from NAUDIT: Service and Traffic Monitoring System

This innovation will oversee monitoring the system at the network layer, watching which service is being provided by the underlying layers. The obtained measurements will be made available to the monitoring and data analytics system, which can also request active measurements. These elements are needed to achieve objective 6 of the project (to design monitoring with big-data analytics framework supporting cognition). The main innovation is related to the development of 100 Gbps probes.

4.9.1 Novelty in Metro-Haul

Naudit had previously participated in other EU projects, such as FP7 Idealist or H2020 dReDBoX. It is clear that those projects have provided the needed previous know-how on high-speed network monitoring to start our current development, but in these projects, NAUDIT worked at lower speeds, such as 10Gb/s, being network monitoring at 100Gb/s our main goal in this project. This speed increment from 10 to 100 Gbit/s is challenging, and not a minor improvement, as our previous developments were based on commodity servers, and now a mixed approach with FPGA is needed to reach this data rate without packet losses.

4.9.2 Use Cases

Our business goal is to provide our clients network monitoring appliances able to solve all their future network problems (network health, application performance, security) at a reasonable cost, being also capable of dealing with 100 Gbit/s network infrastructure. Target clients are those at least having a moderately complex IT infrastructure, typically big companies in the banking, telecommunications, energy and healthcare sectors. We envision that by the end of the project (2020), our clients will have 100 Gbit/s infrastructure up and running so that the timeline of the project matches reasonably well our needs. In fact, we are already finding clients (mainly telco operators) that have this gap in network monitoring, because they do not find affordable monitoring solutions for 100 Gbit/s links that can monitor what traffic is traversing such link, aggregated in VLANs or even flows, and what KPIs are above or below reasonable thresholds.

4.9.3 Intellectual property rights

Given that Naudit development is mainly based on software that is loaded in specialised hardware from third parties, we do not currently have plans to fill any patent, given that software patents are not allowed in Europe. We will use another type of IPR, such as software licenses and industrial secrecy.

4.10 Innovation from POLIMI: VNF Placement Algorithms

The software module integrates with an SDN/NFV control system of a metro network. It receives inputs from the service orchestrator and the SDN controllers in terms of VNF-chain and connection requests. It relies upon machine-learning algorithms for optimisation. It returns to the network control plane suggestions for joint IT/network resource optimisation. It may be used also to suggest periodic rearrangements based on traffic predictions.

4.10.1 Novelty in Metro-Haul

The innovation is associated to an activity originated with MH

4.10.2 Use Cases

The compelling use cases that motivate the innovation is the need for a network operator/service provider to keep the resource allocation of its networking/IT infrastructure optimal or close to optimal in any moment in order to save on OpEx (and possibly also on CapEx)

4.10.3 Intellectual property rights

There are no patents associated to the activity

4.11 Innovation from Infinera Portugal (Coriant): System for Autonomic Optical Channel Provisioning

A system comprising (1) workflows for real-time monitoring and/or estimating optical performance information in a live optical network and (2) machine learning models to predict the optical performance of upcoming optical channels. After an initial training stage, the autonomic optical channel provisioning system is used for validation of optical channels, having as key advantages over traditional optical validation strategies: faster execution and lower processing and storage requirements.

4.11.1 Novelty in Metro-Haul

In-house concept development done within the scope of Metro-Haul, built upon some practical machine learning for QoT use-cases demonstrated in Metro-Haul

4.11.2 Use Cases

Accurate real-time optical channel validation with abstracted view of network parameters (e.g. suited to disaggregated scenarios). Addressable as stand-alone application or through inclusion in network control software suites.

4.11.3 Intellectual property rights

A patent has been filed.

Title: High-Precision Fast Performance Evaluation in Optical Networks

Date: 5/17/2019

ID: EP 19175153.6

Status: Filed

4.12 Innovation from Infinera Portugal (Coriant): Configurable and Disaggregated Metro Network Design and Deployment

Development of a node architecture based on compact, power-efficient and disaggregated plug-and-play modules (e.g., amplifiers, WSS, add/drop filters) for dynamic configuration of low-cost metro networks, enabling incremental network upgrades from fixed-filter to flexible ROADM using the same platform. Development of a network optimisation framework to leverage hybrid fixed/flexible configurations for lowest cost network design.

4.12.1 Novelty in Metro-Haul

Hardware development performed in-house independently of Metro-Haul. Network optimization software developed within Metro-Haul for in-house planning and project-wide techno-economic evaluation.

4.12.2 Use Cases

Low-cost deployment of flexible and disaggregated pay-as-you-grow optical metro solutions. Optimization capabilities to exploit mixed-platform (e.g. node architecture) planning for optimal cost offerings.

4.12.3 Intellectual property rights

No IPR has been filed so far.

4.13 Innovation from Nokia IT (NI): SDN Application for managing spectrum fragmentation in a multilayer optical network

The proposed spectrum fragmentation application will monitor the fragmentation state of the network at the WDM layer and point out the links that present a high fragmentation state. A fragmentation operation is run following network operator specification that will be specified using a web-application (e.g., defining the maximum tolerated link fragmentation and the minimum time interval between two consecutive reconfigurations.

4.13.1 Novelty in Metro-Haul

Nokia investigates the capability of optically reconfigure the network for allowing network defragmentation. Because of the ever-huge capacity of optical channels, the optical reconfiguration risk to jeopardize high quality services or not be possible because of the loss of data. To overpass this issue, Nokia aims at exploiting the free capacity in already set-up optical channels and reconfigure over them high priority services through OTN layer.

4.13.2 Use Cases

Nokia proposes to use the quality of service and the reconfiguration at layer 1 (OTN Layer) for enhancing the capability of the overall network defragmentation. To act on the electrical layer allows fast and reliable reconfiguration of services having a high quality of service, in this way optical reconfigurations will only impact services with low quality of service and defragmentation operations will be easier to do.

4.13.3 Intellectual property rights

No IPR has been filed

4.14 Innovation from Nokia (NLBF): Low-cost Low-energy Metro Transponders with Low-resolution DAC and/or ADCs

Nokia Bell Labs investigates the opportunity of lowering the resolution of DAC and ADC down to 4 bits or even 3 bits to propose low-cost low-energy metro solutions. First, we assessed quantisation penalties resulting from the low-resolution. Then, we proposed new solutions for mitigating these quantisation penalties whenever possible.

4.14.1 Novelty in Metro-Haul

The Low-cost Low-energy Metro Transponders with Low-resolution DAC and/or ADCs is a new idea started within METRO-HAUL project

4.14.2 Use Cases

Nokia proposes to reduce the resolution of the DAC and ADC to limit the power consumption drastically. Quantisation penalties could be acceptable in metro networks as the length of a path is somewhat limited (a few hundreds of km)

4.14.3 Intellectual property rights

No IPR has been filed.

4.15 Innovation from Nokia (NLBF): Automated Network with Monitoring and Machine Learning

Nokia Bell Labs is very interested in automating the network. We believed that automated networks could be pushed further with the help of artificial intelligence and machine learning in addition to monitoring. However, the design and implementation of automated networks highly depend on the use cases. We proposed architecture with three different complexity of physical layer intelligence according to two main requirements: low latency and cognition.

4.15.1 Novelty in Metro-Haul

The innovation approach leverages Nokia SOP monitoring testbed already built, and we extend monitoring and real-time capabilities to be able to predict the BER a few ms in advance. Hence, we propose the autonomic transmission based on this. We also explore new architectures solutions within METRO-HAUL for an automated network with monitoring and machine learning. The innovation can be view as a critical improvement in terms of added functions of what already developed within the Nokia research activity.

4.15.2 Use Cases

Nokia proposes an autonomic transmission by predicting a few ms in advance the BER according to some physical layer measurements (State-of-polarization so far) so to speed up the performance optimisation procedures.

4.15.3 Intellectual property rights

No IPR has been filed so far.

4.16 Innovation from ADVA and HHI: SDN application for proactive soft-failure detection

The innovation is an analytics application enabling cognitive network assurance through proactive soft-failure detection. In particular, we will cater to real-life network fault use cases and identify them using the ML framework.

4.16.1 Novelty in Metro-Haul

In the context of network assurance, different reliability modelling and prediction approaches have been developed, ranging from empirical methods to physical failure models for systems, subsystems and devices. While the accuracy has been enhanced, challenges like the costs and the complexity of failure modelling exist, together with the need for detailed engineering information and a knowledgeable team of experts. In METRO-HAUL, ADVA with HHI instead proposes a novel data-driven approach to failure mode analysis, explicitly predicting system failure based on optical power and laser degradation analysis. ADVA and HHI follow a learning approach from historical performance data, without explicit modelling, and use an ML model to predict imminent failure proactively.

4.16.2 Use Cases

Software-defined networking proposes centralised network management to enhance network programmability by separation of data and control plane. Likewise, network monitoring and analysis approaches have been reported using both distributed and centralised frameworks. However, most of these networks operate based on static pre-defined configurations which may be engineered, planned, installed, configured, and maintained by human experts. Our proposed model shall be integrated into ADVA's SDN framework, allowing for proactive failure analysis, aiding in improved network assurance.

4.16.3 Intellectual property rights

No IPR has been filed so far.

4.17 Innovation from ADVA and BT: Demonstration of Multi-domain, Multi-layer Network for Support of Sliceable Wholesale Services for Mobile Network Operators

The innovation aims to demonstrate how edge computing and network slicing can enable emerging 5G applications, highlighting how network slices can span across multiple operators' domains. The innovation enables third-party transport network providers to offer fronthaul, backhaul and core connectivity services as well as edge compute capabilities supporting the same slicing techniques as the overall transport architecture. The demo underscores how orchestration technologies are required to compose end-to-end slices.

4.17.1 Novelty in Metro-Haul

ADVA has developed the edge computing for the 5G transport network, while BT has implemented the orchestration to manage different networks slices over a single optical transport infrastructure.

4.17.2 Use Cases

Network slicing capability to offer end-to-end service slices across multiple operators' domains

4.17.3 Intellectual property rights

No IPR has been filed so far.

4.18 Innovation from ADVA: Silicon Photonics Modulator for Coherent Transceiver

Some modelling work for a SiPh modulator which is developed together with another BMBF funded project is performed. The modulator will enable future low-cost 600 Gbit/s coherent transmission, which can also be deployed in metro network scenarios and is intended to become part of an ADVA transponder product.

4.18.1 Novelty in Metro-Haul

ADVA investigated different designs of a SiPh modulator for coherent transmission. This modulator design is new and not implemented in any product so far. Part of the modelling of the modulator was done in Metro-Haul.

4.18.2 Use Cases

The modulator will enable low-cost coherent transponders/pluggable to be used in Metro networks.

4.18.3 Intellectual property rights

No IPR has been filed so far.

4.19 Innovation from ADVA: SDN-Enabled Flexi-grid Optical Domain Controller based on NETCONF/YANG

The Flexi-grid optical domain controller is newly developed SDN component for ADVA's coherent transponders. The proposed modular architecture, based on Finite State Machines (FSMs), allows the flexibility to deploy the controller either in a centralised or in a distributed state for on the fly encrypted device management connections.

4.19.1 Novelty in Metro-Haul

ADVA has developed a Flex-Grid capable Optical Domain Controller for disaggregated optical networks. The API of the Optical Domain Controller is based on NETCONF / YANG and is supporting open, standardised YANG models such as the ONF Transport-API. Additionally, ADVA's disaggregated transponders will support OpenConfig as device-level SDN APIs. This optical network control is being developed and tested in the ONF Open Disaggregated Transport Network (ODTN) project. The Optical Domain Controller will be integrated as a new feature into ADVA's commercial Network Management System "Ensemble Controller".

4.19.2 Use Cases

Multi-vendor SDN-control of disaggregated optical networks. ADVA also contributes to standardisation, participates in Multi-vendor field trials.

4.19.3 Intellectual property rights

No IPR has been filed so far.

4.20 Innovation from ADVA: NETCONF-based Low Latency Cross-connect for 5G C-RAN Architectures

An SDN controller for an optical cross-connect (existing ADVA product) is developed, demonstrating a NETCONF protocol including a YANG model describing the optical cross-connect. This cross-connect is also evaluated, and it is proved that a cost-effective OEO implementation can fulfil the stringent requirements of radio interfaces such as CPRI in terms of latency and jitter at various bandwidths.

4.20.1 Novelty in Metro-Haul

ADVA has developed a NETCONF-based low latency Cross-connect for 5G C-RAN architectures as an effective OEO implementation that can fulfil the stringent requirements of radio interfaces such as CPRI in terms of latency and jitter at various bandwidths. The NETCONF-based API allows the cross-connect to be integrated into SDN control frameworks and SDN controllers with NETCONF-based SBI.

4.20.2 Use Cases

The cross-connect can be used as a prototype for 5G trials to measure KPIs for CPRI transport. However, at the moment, there is no plan to continue the development in the project, but to focus on other innovations.

4.20.3 Intellectual property rights

No IPR has been filed so far.

4.21 Innovation from Ericsson (TEI) and CNIT: Integrated Photonics White Box

Ericsson will exploit photonic integrated components such as the switching matrix already available from IRIS FP7 European Project. Such components will be conveniently included and tested in an optical Whitebox for the high capacity optical node, connected in a metro network acting as back-haul of 5G network.

4.21.1 Novelty in Metro-Haul

Ericsson Research has realised a new prototype of Open ROADM optical node in collaboration with CNIT. The hardware is based mainly on the use of the silicon photonics technology and is the outstanding realisation achieved by Ericsson in another European project, FP7 IRIS in 2018. The primary wavelength switch is the realisation of 1000 thousand switching functions all integrated into a single millimetre-square photonic chip. In Metro-Haul the IRIS hardware is now part of a Whitebox designed with CNIT.

4.21.2 Use Cases

The Whitebox innovation is defined for agile and flexible deployment of the network service leveraging on virtual and software-based infrastructure. The so defined infrastructure is an integral part of the metro scenario evolution for 5G transport applications.

4.21.3 Intellectual property rights

No IPR has been filed so far. However, prior art, mainly linked with the photonic hardware used by Ericsson, has been shared among partners with fair, reasonable, and non-discriminatory terms and in line with the Consortium Agreement.

4.22 Innovation by Ericsson (TEI) and CNIT: Agent for an Integrated Photonics White Box

Ericsson will use an SDN-enabled network solution in conjunction with CNIT to drive the Whitebox, encompassing the integrated photonic switch already available from the European IRIS FP7 project. The proper characterisation in a test bench of optical transport will be carried out for exploitation in real network scenarios.

4.22.1 Novelty in Metro-Haul

The innovation is entirely associated with an activity that originated with Metro-Haul.

4.22.2 Use Cases

The primary use case is the exploitation of the agent defined in an SDN enabled network solution operating in the metro network acting as back-haul of 5G network.

4.22.3 Intellectual property rights

No IPR has been filed; the innovation is mainly based on software that is loaded in specialised hardware.

4.23 Innovation from Ericsson (TEI) and CNIT: Integrated Photonics Tunable Optical Dispersion Compensator

Ericsson, together with CNIT, is realising an integrated optical dispersion compensation module (ODCM) realised on a Silicon photonics (SiP) platform. The innovation is the realisation of an integrated photonic device.

4.23.1 Novelty in Metro-Haul

The innovation is entirely associated with an activity that originated with Metro-Haul.

4.23.2 Use Cases

The SiP ODCM can receive and separate a polarisation multiplexed (PolMux) signal in the C-band (ITU-T 100Ghz DWDM grid) and compensates for the chromatic dispersion accumulated on different single-mode fibre (SMF) spans.

4.23.3 Intellectual property rights

No IPR has been filed so far. However, prior art, mainly linked with the photonic circuit used by Ericsson, has been shared among partners with fair, reasonable, and non-discriminatory terms and in line with the Consortium Agreement.

4.24 Innovation from Ericsson (TEI) and CNIT: Agent for an Integrated Photonics Tunable Optical Dispersion Compensator

Ericsson, together with CNIT, realises the agents interfacing an integrated optical dispersion compensation module (ODCM) realised on a Silicon photonics (SiP) platform.

4.24.1 Novelty in Metro-Haul

The innovation is entirely associated with an activity that originated with Metro-Haul.

4.24.2 Use Cases

The compelling use case is the setting of the operative conditions of the needed interface to connect a fully integrated photonic device to an integrated photonic Whitebox.

4.24.3 Intellectual property rights

No IPR has been filed; the innovation is mainly based on software that is loaded in specialised hardware.

4.25 Innovation from Qognify (Seetec): Video Surveillance on the network edge

Video-surveillance recording-servers are often on poles near a cluster of cameras to save bandwidth. An alternative is to run a unique purpose fibre loop around cities. Both options are expensive in construction or ongoing maintenance, prevent surveillance projects or limit their size. The innovation is to connect cameras via 5G network with recording-servers reside in AMEN nodes on the network edge. Low latency will further allow new functions as the automatic following of objects between cameras.

4.25.1 Novelty in Metro-Haul

Low latency is a key factor in operating a tracking camera (PTZ = pan tilt zoom) remotely. If tracking is done manually by an operator, the latency can be compensated for in a limited way by reducing the movement commands sent by the operator to eliminate an overshoot as a result of the time lag. A more complex scenario is if the operator is a machine and not a human.

4.25.2 Use Cases

The following scenario is not uncommon: One or more thermal cameras are mounted on the top of a building overlooking the surrounding parking lot or entrance area. Closer to ground level PTZ cameras will track a person detected by the camera located on top of the building. The thermal camera detects the person and tracks the movement. The PTZ camera helps identify the person and the individual activities. The maximum latency for the round trip is 10-50 ms. In a small installation all the controlling and recording software will be located in the building that is being monitored. In a city-wide installation, the controlling hard and software will be located in a central data center. In a large city or urban area with millions of people the data center may not be in the same network node. The current state of the art does not allow such a scenario.

Cameras with Pan-, Zoom- and Tilt- (PTZ) capability are often used to obtain a larger image of a person in an open space such as a parking lot, or perimeter of a building. Some cameras are able to autonomously track a person's movement. However, this is limited as the tighter the image is, the more difficult it is to track an erratically moving object. One solution to overcome this problem is to have one camera with a wide angle lens that is fixed and has video analytics to detect and track a moving person. A second camera with PTZ capabilities is remote controlled by the first. The fixed camera is chosen to be a thermal camera, so that tracking will also work in darkness. More than one PTZ camera can be controlled by the fixed camera.

4.25.3 Intellectual property rights

This development is mainly based on software that is loaded in specialised hardware from third parties. We do not currently have plans to fill any patent, given that software patents are not allowed in Europe. We will use another type of IPR, such as software licenses and industrial secrecy.

4.26 Innovation from HHI: Licensing of IP

Fraunhofer licenses its IP to companies. In particular, Fraunhofer cooperates with companies (preferably SMEs) to provide products to end customers. One example of such cooperation is the VPItoolkitTM DSP-Library, which is developed together with VPIphotonics GmbH. The DSP-Library is expected to benefit from the work performed in WP3 of METRO-HAUL.

4.26.1 Novelty in Metro-Haul

We demonstrated a novel perturbation-based fibre-nonlinearity compensation technique and evaluated its performance in metro-reach system experiments. The achieved gains in Q2-factor are comparable to digital back-propagation over a wide range of symbol rates and pulse-shapes. The algorithm is suited for real-time implementation on ASICs due to its low complexity for practical system scenarios.

4.26.2 Use Cases

Modelling and simulation of optical transmission systems, DSP algorithm design and verification, Benchmark DSP algorithms, Design of next-generation transceivers, Address trade-off between DSP complexity and its performance, compare modulation formats, System performance analysis, define component requirements, real-time implementation.

4.26.3 Intellectual property rights

Patent application pending. Inventors are:

Felix Frey (University of Ulm / Fraunhofer HHI)

Robert Fischer (University of Ulm)

Johannes Fischer (Fraunhofer HHI)

The title is: APPARATUS AND METHOD FOR TRANSMITTING AND/OR RECEIVING DATA OVER A FIBER-OPTICAL CHANNEL EMPLOYING PERTURBATION-BASED FIBER NONLINEARITY COMPENSATION IN A PERIODIC FREQUENCY DOMAIN

4.27 Innovation from HHI: 5G Berlin Innovation Cluster

One of the Metro-Haul final demonstrators will be performed within the 5G Berlin testbed, a unique and open infrastructure for 5G end-to-end testing in Berlin. Fraunhofer is one of the founding bodies of the 5G Berlin Innovation Cluster, a non-profit organisation running the 5G Berlin testbed. The lively start-up scene in Berlin will have the opportunity to develop and test their new 5G applications and services on that infrastructure, providing another route for the exploitation of METRO-HAUL results.

4.27.1 Novelty in Metro-Haul

Within Metro-Haul, the use case of public safety by intelligent video analytics is going to be demonstrated partly based on infrastructure of the 5G Berlin testbed. To this end, the 5G Berlin testbed is augmented by video sources (wired and wireless), video management and analytics solutions as well as optical equipment and distributed compute resources. This will enhance potential future service offerings for this open infrastructure and test platform.

4.27.2 Use Cases

Public safety by intelligent video security is provided by low-latency video analytics on edge cloud infrastructures integrating together radio access networks, optical networks and edge compute principles in a single use case demonstrator. This open infrastructure can be made available to stakeholder who would like to test their solutions in a 5G network environment.

4.27.3 Intellectual property rights

No IP expected.

4.28 Innovation from Zeetta: Orchestrating 5G services over dis-aggregated Metro-Haul Network

Zeetta promotes Metro-Haul software orchestration development, which will enhance Zeetta's existing product features on the control and management of disaggregated networks. Zeetta will implement Metro-haul Orchestration features in their products and deploy real-world PoC to demonstrate the orchestration benefits over Metro-Haul based network for 5G services. Plans are to showcase Metro-Haul PoC results in Telecom Infra Project-18/19, Open Network Summit-18, Mobile World Congress-19; SDN Layer123, OFC 2020 and Bristol demo.

4.28.1 Novelty in Metro-Haul

Orchestration and management with SDN control and NFV resource scheduling over metro, transport and access networks. By introducing SDN management and decoupling control from data plane - the process of service deployment is greatly simplified while CAPEX and OPEX are reduced. End-to-end service providing video streaming capabilities over UK's NDFIS network. Disaggregated optical network hardware was introduced into the NDFIS for showcasing 5G KPIs and reduced time in service provisioning. Hierarchical SDN controller architecture and orchestration.

4.28.2 Use Cases

The first use case: Crowdsourcing video streaming between remote locations. The second use case: Network connectivity provisioning with significantly reduced timings. 3rd use case: Decoupling of control and data plane in heterogeneous data transport networks. 4th use case: Hierarchical SDN controller architecture where each controller is responsible for controlling of different network components. Vertical controller interaction.

4.28.3 Intellectual property rights

No IPR has been filed so far.

4.29 Innovation from UC3M, POLIMI and TID: Applications of Machine Learning algorithms in optical networks

The use of classical supervised Machine Learning techniques, after trained with a large number of optimal control-plane configurations from past activity and experience, can be used to rapidly procure optical network configurations without the need to re-calculate all network parameters, just a copy and paste from experience results.

4.29.1 Novelty in Metro-Haul

The innovation is entirely associated with an activity that originated with Metro-Haul.

4.29.2 Use Cases

The use cases that motivated the innovation/invention originate from the needs of telecom operators to address Traffic Engineering tasks dynamically, upon traffic changes thus providing a close-to-optimal solution within a few milliseconds, while waiting for an optimal solution provided by the ILP formulations of RWA, which may take several seconds or minutes depending on the network size.

4.29.3 Intellectual property rights

No IPR has been filed so far

4.30 Innovation from TIM, BT and TID: Guidelines for rethinking the architecture of Central Offices applying disaggregation and softwarization paradigms

The target of this innovation action is developing new skills and tools for the transition from traditional COs to new ones based on data centre like architecture, leveraging on disaggregation solution down to the optical layer, virtualisation and network automation. The final goal is the introduction to provide cost-effective solutions supporting 5G and edge storage and computing. Metro-Haul could be very helpful to address this issue in TIM real networks.

4.30.1 Novelty in Metro-Haul

More specifically, leveraging on METRO-HAUL innovation by TIM on the NETCONF Agents for Optical Devices, emulated OpenROADM and OpenConfig devices have been realised running in “Docker containers”. In Metro-Haul, with the last version of the ONOS controller, TIM is emulating an Italian metropolitan network. These activities are based on the emulated environment almost wholly developed within the framework of METRO-HAUL.

4.30.2 Use Cases

The use cases of the innovative emulated environment are:

- Testing load of ONOS/OpenDaylight controller in an emulated but realistic disaggregated environment;
- Evaluate the maturity of the controlling environment;
- Test the integration with planning and configuration tools;
- Evaluate the integration with orchestrators and disaggregated central offices.

4.30.3 Intellectual property rights

No IPR has been filled as the innovation is designed to be “open software” within METRO-HAUL to foster enhancing of the number of OpenROADM compliant prototypes. At the end of the project, we are considering a possible public release of the software to help the open community in developing emulated testing devices.

4.31 Innovation by TU/e: A multi-purpose loss-less photonic integrated wavelength selective switch (2 to N degrees)

The innovation consists of a low-cost SOA based 2-degree ROADM with the function of switching and amplification. The SOA gates inside the ROADM can be turned on and off by the FPGA based O/E/O interface to make each single wavelength pass/stop or drop & continue. It will uses an SDN-enabled network solution in conjunction with an OpenROADM agent to drive the metro-access node.

4.31.1 Novelty in Metro-Haul

The innovation is entirely associated with an activity that originated with Metro-Haul.

4.31.2 Use Cases

The SDN reconfigurable metro-access ring based on SOA 2-degree ROADM nodes with edge-computing and network slicing interfaces can successful control dynamic network slicing generation, add/drop functionality, bandwidth and edge-computing resources assignment to fulfil specific requirements of 5G applications.

4.31.3 Intellectual property rights

No IPR has been filed.

5 Contributions from partners in support of Metro-Haul Innovation

Several demos in support of Metro-Haul innovation has been showcased in the important events around Europe. The demos organised by TIM can represent an excellent example of commitment to innovation. For instance, by utilising the NETCONF Agents for Optical Devices, part of innovation by TIM described in 3.2, TIM has realised several testbeds and demos including:

- ECOC 2018 demo realised in collaboration with CTTC, showing a Carrier Ethernet service provided on a disaggregated multi-layer network featuring CORD-based nodes interconnected by an optical network based on TIM prototype ROADMs (OpenROADM compliant) and Infinera Groove transponders, controlled by a hierarchical structure of ONOS controllers.
- EUCNC 2019 METRO-HAUL "Leveraging multi-layer network slicing for improving public safety” demo where a couple of emulated ROADMs (based on the same software used for controlling the TIM’s prototypes) were included in the (emulated) optical metro network.
- EUCNC 2019 joint METRO-HAUL, 5G-Picture demo (See Figure 1) realised in TIM laboratories and involving real devices from TIM (prototype ROADMs, OpenROADM compliant) and Bristol (software configurable transponders, OpenConfig compliant) and last version of ONOS controller with all the new features introduced by METRO-HAUL.

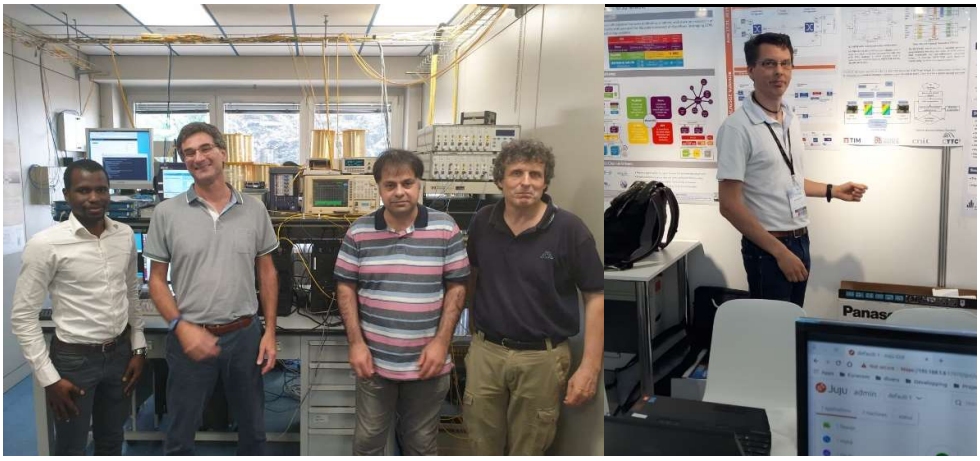

Figure 1 EUCNC 2019 demo: left: TIM, Bristol guys in TIM labs; right: TIM guy presenting at EUCNC

At EUCNC 2019, a multi-partner demonstrator joining two different European projects (joint 5G-PICTURE and METRO-HAUL demo) has been showcased, with the participation of TID, CTTC, UPC, University of Bristol, Universidad Politécnica de Cartagena, TIM, Politecnico di Milano, ADVA Optical Networking, SeeTec, Fraunhofer Heinrich Hertz Institute, CNIT. The demo was a proof of concept for the integration of the dynamic packet switching and optical transport node (TSON) concept developed within 5G-PICTURE and the optical disaggregation approach fostered by METRO-HAUL, into a dynamic transport network, whose configuration is fully automated by an SDN control plane. The demo is wholly based on devices developed within the two projects and leverage on open source software for devices and network control.

Worth of note, the above initiatives were the results of tight collaboration among industrial and academic partners. Other worth note examples of the same kind have been suggested and organised by CTTC around the world as those showcased at OFC 2019 [Campanella], [Esmenats].

Among the dissemination initiatives to support the project vision on innovation, Antonio D'Errico with Ericsson and Albert Rafael with British Telecom, representing Metro-Haul Project, with the collaboration of Stephen Grubb with Facebook Inc., chaired the Open Platform Summit on Disaggregated Networks at OFC 2019 HELD IN San Diego, California, see Figure 2 [Summit].

The major players in the field were present at the summit: AT&T, Microsoft, NTT, Facebook, ONF representative.

The summit was organized in two sections. First, five invited speakers began with their perspectives on network disaggregation and how it may drive network deployments in the near future. In the process, they outlined progress in initiatives such as Open ROADM, Telecom Infra Project, OpenConfig and ONF. Immediately following was a robust discussion focusing on the objectives and different strategies leading to the design and deployment of more efficient, more cost-effective, greener and more sustainable network infrastructures, thus achieving a more flexible ICT services evolution in the future.

Figure 2 People participating in the Open Platform Summit at OFC 2019 event in San Diego

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