IDEALIST: Standardization and dissemination activities in the second half of the project

Status and Version:	Standardization and dissemination activities in the second half of the project	
Date of issue:	30.10.2015	
Distribution:	Public	
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Abstract

The present document describes the dissemination and standardization activities that have been carried out in the IDEALIST project during its second half of life. Such activities have been realized under the responsibility of Workpackage 6 "Project Impact".

Executive summary

IDEALIST results in terms of dissemination and standardization of the achievements in the project are significantly exceeding the original targets.

The complete list of IDEALIST publications can be found in the attached Excel file as well as at project website (http://www.ict-idealist.eu/index.php/publications-manager).

IDEALIST publications

Following figures summarize the strong IDEALIST impact on dissemination:

Type of publications	Number
Conference/Workshops	192
Journal/Magazine	92
Standards	30
Total	314

Such a huge number of publications is mainly due to the application of the following dissemination policies within the project:

- **External peer review of technical results**. All technical contributions to deliverables were submitted to journals, conferences or standardization bodies in order to assure their technical quality (i.e external peer review).

- **Dissemination organization at Task, WP and project levels**. More than 100 joint papers involving multiple partners were published during project lifetime. This figure demonstrates the deep collaboration among partners and WPs.

Among the multiple IDEALIST publications, we can highlight the following project positioning papers:

Title	PublicationName / Standard	Institutions
IDEALIST control and service management solutions for dynamic and adaptive flexi-grid DWDM networks	FUNEMS 2015	TID,TI,ALBLF,CTTC,TE,NAU,CNT,ODC,CS,ALU-I
Elastic Optical Networks the Vision of the ICT Project IDEALIST	FUNEMS 2013	TID,TI,ALBLF,CTTC,DT,TE,CORTDE,CNT,COR,UNIVBRS,HHI,TU/e,ALU-I
In-Operation Network Planning	IEEE Com. Mag.	TID,CTTC,UPC,ODC,CS
Multi-Layer Capacity Planning for IP-Optical Networks	IEEE Com. Mag.	TID,DT,CS
Next Generation Elastic Optical Networks: the Vision of the European Research Project IDEALIST	IEEE Com. Mag.	TID,TI,ALBLF,CTTC,TE,CORDE,CNT,UNIVBRS,UoP,HHI,TU/e
Next Generation Sliceable Bandwidth Variable Transponders	IEEE Com. Mag.	TID,TI,BT,CTTC,TE,CORTDE,CNT,UNIVBRS,HHI,TU/e,ALU-I
IDEALIST Control Plane Architecture for Multi-domain Flexi-Grid Optical Networks	EUCNC 2014	TID,TI,CTTC,CNT,ODC
Next Generation Optical Nodes: The Vision of the European Research Project IDEALIST	IEEE Com. Mag.	TID,TI,TE,CORDE,CNT,UNIVBRS,UoP,TU/e,ALU-I
A Service-Oriented Hybrid Access Network and Clouds Architecture	IEEE Com. Mag.	TID,TI,CNT,UPC,UoP
Experimental Assessment of ABNO-Driven Multicast Connectivity in Flexgrid Networks	JLT	TID,CNIT,UPC
Next Generation Sliceable Bandwidth Variable Transponders	IEEE Com. Mag.	TID,TI,BT,CTTC,TE,CORTDE,CNT,UNIVBRS,HHI,ALU-I
Routing Codica and Spectrum Assignment (RCSA) in Elastic Optical Networks	JLT	TE,CNT
Vendor-interoperable Elastic Optical Interfaces "standards, experiments and challenges"	JOCN	DT,TE,CORDE,CNT,TU/e,CORPT
Multi-partner Demonstration of BGP-LS enabled multi-domain EON control and instantiation with H-PCE	JOCN	TID, TI, CTTC, CNT
Experimental Demonstration of Multi-vendor and Multidomain Elastic Optical Network with data and control interoperability over a Pan-European Test-bed	JLT	TID, CTTC, UPC, TI, TUE, CORIANT, ALBLF, UNIVBRS, CNT, TE, NAUDT

Other relevant IDEALIST dissemination actions reported in this deliverable were:

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- Elaboration of the IDEALIST book including a detailed description of main projects results (algorithms, planning, network architectures, transmission, control plane, etc)

- IDEALIST workshops at ECOC 2015 in collaboration with DISCUS and STRAUSS

- IDEALIST integrated testbed demonstration and post deadline paper at ECOC 2015 "First Demonstration of Multi-vendor and Multi-domain EON with S-BVT and Control Interoperability over Pan-European Testbed".

Internet standardisation is often an arduous and long process, thus ensuring Standard Development Organisation (SDO) output is useful to the industry at large, solves specific near-term problems and of sufficient quality that it may be used (i.e., implemented by vendors and deployed by operators around the world). Our numerous IDEALIST SDO contributions have translated into actual standards, with three current RFCs and a number of additional proposals nearing completion in the standardisation queue, and therefore likely to make RFC status before the end of 2015.

Thus we can conclude, the IDEALIST standardisation efforts have been a significant success. They demonstrate that the IDEALIST project has had purposeful impact on industry with the adoption and formal publication of our ideas as industry standards (specifically Internet Engineering Task Force RFCs and ITU-T updates to key flexi-grid developments).

Contents

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1. Introduction

The purpose of the document is to illustrate the results of the standardization and dissemination activities in the second half of the project activities undertaken by the IDEALIST project consortium.

Main dissemination activities (i.e conference and journal, papers, miniconferences, newsletter, workshops, training, etc) are summarized in Section 2, while standardization contributions at IETF and IT-T are reported in Section 3.

All IDEALIST contributions on dissemination and standardization activities are available at project website (http://www.ict-idealist.eu/index.php/publications-standards).

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1. Dissemination

1.1 Objectives and Overview

This part documents key activities of the IDEALIST consortium in order to disseminate the technological leadership of European industry and academia in flexgrid and flexrate optically elastic technology to the networking community worldwide.

This demonstrates the success of this project that greatly relies on publications widest possible dissemination of its achievements. While here IDEALIST did also an exceptionally successful job, not all activities could be explicitly mentioned as they were too many. Consequently, the following sections provide only a spotlight overview on essential activities with major impact.

Therefore, the following sections are organized in general training events, such as tutorials, and specific internal mini conferences done online by Webex sessions. Then relevant high-impact publications at conferences proceedings as well as peer-reviewed journals and magazines are listed. Then, the newsletter, the IDEALIST book and contributions to international workshops are introduced. Finally, further partner-specific dissemination activities are summarized.

1.2 Training Activities

Training activities comprise tutorials and workshops given at international events like ECOC 2015, "Next Generation Optical Networking" event in Nice or "Photonics in Switching" conference in Florence. Furthermore, project-internal so-called mini conferences have been held by the use of Webex sessions.

1.2.1 Specific Training Events

OldDog

- ECOC is the leading Optical Conference for European researchers and attracts wide attendance from outside Europe as well. This year IDEALIST created a Sunday workshop entitled "SDN & NFV: Real value with new business opportunities or research hype with unmanageable complexity?". Our focus was to discuss network programmability based on Software-Defined Networks (SDN) and Network Function Virtualization (NFV), two topics that are demonstrating major trends in optical network research and standardization.

  Since the initial focus on the OpenFlow protocol as a new southbound interface to directly control the forwarding plane of packet switches, IDEALIST has helped, via Adaptive Network Manager and Application-Based Network Operations architecture, to show that SDN is gaining increased importance as new networking paradigm allowing virtualization and programmability based on hardware abstraction and open programming interfaces.

  As shown in this summary document new SDN architectures and protocols are being proposed and discussed in the IETF, e.g. northbound protocols for topology dissemination and service orchestration. NFV is increasing the flexibility even further by moving network functions from dedicated hardware to virtual machines. This new degrees of flexibility pose opens a set of new challenges and research issues, ranging from service orchestration, security, reliability, etc. Our ECOC workshop

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highlighted how SDN and NFV might simplify the way optical access and core network are operated, current art and future grand research challenges.

In addition to IDEALIST principles the ECOC workshop brought together views from other recent FP7 and ongoing research projects (e.g., STRAUSS, IDEALIST, DISCUS, COMBO) as well as Industrial actors (both network operators and vendors) on hot topics and current trends in SDN and NFV. The format was based on topics presented in the form of invited talks of 15 minutes. A moderated panel discussion both for research and industrial dealt with the topical subjects, our agenda is as shown below:

- o "SDN Orchestration of Multi-domain and Multi-vendor Transport Networks", Ricard Vilalta CTTC, Spain

- o "An Architecture, Protocols and Information Models for SDN in Flexi-Grid Optical Networks", Adrian Farrel Old Dog Consulting, UK

- o "SDN & NFV for Distributed Core Seamlessly Integrating Wireless and Fixed Optical Network", Victor Lopez Telefónica, Spain

- o "NFV-based Universal Access for Converged Fixed and Mobile Broadband Access/Aggregation Networks", Stephan Pachnicke ADVA Optical Networking, Germany

- o "Path determination as a Key Component of SDN and NFV for Access, Core, Transport and IoT", Francesco Paolucci SSSUP, Italy

- o "SDN and NFV – Views from Japanese Operator", Takehiro Tsuritani KDDI R&D Labs, Japan

- o "From Transport SDN to Multilayer SDN", Gabriele Maria Galimberti Cisco Systems, Italy

- o "SDN-based Scalable Optical Network Management – A case for OpenConfig YANG Models", Vinayak Dangui Google, USA

- o "SDN-based performance monitoring for virtual Network Function (vNF) service chaining", Ming Xia Ericsson Research Silicon Valley, USA

- o "Multi-layer SDN with YANG Data Model for TE Topologies", Dirk Van Den Borne Juniper Networks, Germany

Deutsche Telekom

- A tutorial on "Multi-layer interworking with rate-adaptive (flexrate) transmission technology" was given at the 17th "Next Generation Optical Networking" event in Nice, France, on June 24. It explained the expected benefits and still existing challenges coming along with dynamic multi-layer resilience in aggregation networks when accomplished with next-generation flex-rate transceivers. The audience was an international group of communications experts and analysts.

- At an educational workshop at the 41st European Conference on Optical Communications (ECOC), DT presented their thoughts on "Adaptive Transceivers: Does the operator benefit?". Emphasize was given on a comprehensive description of potential use cases featuring optical recovery mechanisms as well as load-adaptive network operations.

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- Preparation of teaching materials for providing guidance to students (internships, Bachelor and Master degree)

Ericsson (TEI)

- Participation in workshop WS3 on "Photonic Switching Systems" in support of spatially and spectrally flexible optical networking at "Photonics in Switching 2015", Florence, Italy:

  o The IDEALIST FP7 project main aspects and vision were evidenced in the introduction of the talk. The elastic optical network scenario of IDEALIST project was also presented and the main parts of the network node architecture and the programmable Bandwidth Variable Transponder were defined. Details on Terabit superchannel transmission as analysed in IDEALIST were discussed.

  o Concluding, focus was given on the Routing, Code and Spectrum Assignment mainly based on code-adaptive time frequency packing and the relevant blocking probability in future elastic network was clarified.

  o Proposal for IDEALIST view sharing with SPIRIT and ASTRON FP7 Consortia was stimulated at the end of the speech and the IDEALST presentation made by ERICSSON is now available on the websites of FOX-C and INSPACE.
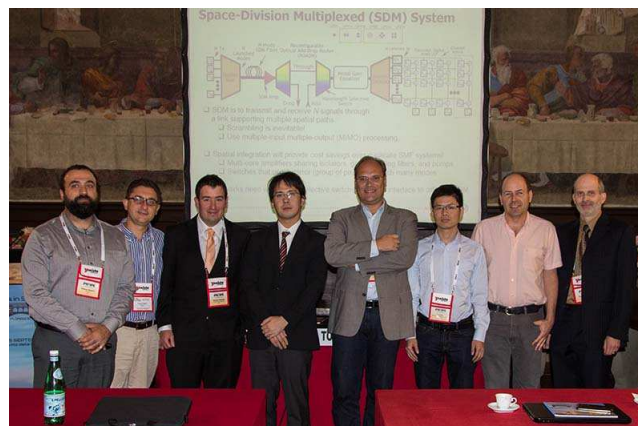

Figure 1: Speakers in the WS3 workshop PS2015, Florence: Roberto Proietti with Uc Davis, US; Antonio D'Errico, with Ericsson, Italy; Paul Colbourne with Lumentum, Canda; Zong Liangjia with Huawei, China; Ioannis Tomkos with AIT, Greece; Ikuma Yuichiro with NTT, Japan; Dan Marom with The Hebrew University of Jerusalem, Israel; Nicolas Fontaine with Bell Labs, US

1.2.2 Mini conferences

The purpose of project-internal mini conferences is to offload the regular technical face-to-face meeting and making them more interactive and more discussion oriented. Therefore, several mini conferences were held in order to share the latest scientific results and achievements, specifically one in July 2014, a further one in September 2014 just before ECOC and finally one in March 2015 just before OFC.

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E.g. a mini conference was held in March just before the optical fiber conference (OFC) in Los Angeles in order to share the latest scientific results and achievements. This gave presenters the chance to pre-check their conference talks with the assistance of the project-internal audience. The events' total duration was 2 hours. After each session there was enough time for several questions and detailed explanations. Being accomplished through online Webex sessions without the need for traveling, these mini conferences are considered as highly beneficial for an extensive and fruitful exchange between partners.

Specifically the following paper have been presented:

- "Impact of Multi-wavelength sliceable transponders in Elastic Optical Networks" (CNIT): The utilization of sliceable bandwidth variable transponders based on multi-wavelength technology is evaluated in EONs. A routing and spectrum assignment scheme is proposed specifically designed to consider the constraints introduced by multi-wavelength technology.
- "Routing, Code, and Spectrum Assignment (RCSA) in Elastic Optical Networks" (CNIT): This paper introduces the concept of code selection in RSA for EONs. Simulations show that code-adaptive time frequency packing reduces blocking probability by one order of magnitude with respect to format-adaptive Nyquist WDM.
- "Proactive Hierarchical PCE based on BGP-LS for Elastic Optical Networks" (CNIT): Hierarchical PCE architecture is considered in multi-domain EONs. A novel scheme is proposed to proactively update the parent PCE using BGP-LS. Simulations show that the proposed scheme reduces blocking probability and parent PCE control load.
- "Novel DAC digital pre-emphasis algorithm for next-generation flexible optical transponders " (Coriant, Germany)
- "Measuring Flexibility and Design Trade-offs of N x M SSS-based ROADMs and BVTs" (UniBris)
- "Function Placement and Configuration for Power Balanced Network Function Programmable Optical Nodes" (UniBris)
- "Experimental validation of MTU-BRAS connectivity with DMT transmission and coherent detection in flexgrid metro networks using sliceable transceivers" (CTTC): Simple and cost-effective DMT transmission in combination with shared coherent detection is proposed for evolutionary flexgrid metro/regional networks. Network testbed experiments show successful 10Gb/s connections from MTUs to the sliceable transceiver at the virtual BRAS farm, covering up to 150km.

1.3 Publications at conferences

IDEALIST innovation activities have been disseminated at flagship conferences, such as ONDM 2014, EUCNC 2014, ICTON 2014, ECOC 2014, OFC 2015, EUCNC 2015, ICTON 2015 and ECOC 2015:

Optical Network Design and Modeling (ONDM 2014), Stockholm, Sweden, May 19 – 22, 2014.

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- Marija Furdek, Matija Džanko, Patrik Glavica, Lena Wosinska, Branko Mikac, Norberto Amaya, Georgios Zervas, Dimitra Simeonidou: "Efficient Optical Amplification in Self-Healing Synthetic ROADMs"

European Conference on Networks and Communications (EUCNC 2014), Bologna, Italy, June 23/26, 2014.

- R. Casellas, et al., "IDEALIST Control Plane Architecture for Multi-domain Flexi-Grid Optical Networks ", a positioning paper on IDEALIST WP3 work regarding the GMPLS/PCE control plane

16th International Conference on Transparent Optical Networks (ICTON 2014), Graz, Austria, July 6-10, 2014.

- António Eira, João Pedro, João Pires: "Cost Sensitivity Evaluation of Fixed/Flexible Rate Line-Cards and Transceivers under Incremental Traffic"

- João Pedro, Sílvia Pato: "On the Value Proposition of the Contentionless Add/Drop ROADM Property in DWDM Transport Networks"

European Conference on Optical Communications (ECOC 2014), Cannes, France, September 21-25, 2014.

- António Eira, João Pedro, João Pires, Juan Fernández-Palacios: "CAPEX Impact of Fixed/Flex-Rate Modular Line Interfaces in Multi-Period Network Planning with Equipment Reuse"

- Miquel Garrich, Eduardo Magalhães, Heitor Carvalho, Andrea Bianco, Paolo Giaccone, Georgios Zervas, Dimitra Simeonidou, Neil G. González, Juliano Oliveira, Júlio Oliveira: "Experimental Demonstration of Backplane Architectures for Programmable Optical Nodes"

Optical fiber conference (OFC 2015), Los Angeles, USA , 22-26 March, 2015.

- K. Walkowiak, R. Goścień, and M. Klinkowski: "Evaluation of Impact of Traffic Asymmetry on Performance of Elastic Optical Networks"

- N. Sambo, G. Meloni, F. Cugini, A. D'Errico, L. Potì, P. Iovanna, P. Castoldi: "Routing, Code, and Spectrum Assignment (RCSA) in Elastic Optical Networks"

- A. Sgambelluri, A. Giorgetti, F. Cugini, G. Bruno, F. Lazzeri, P. Castoldi: "First Demonstration of SDN-based Segment Routing in Multi-layer Networks"

- António Eira, João Pedro, João Pires, Juan Pedro Fernández-Palacios: "Optimization of Client-to-Line-Side Switching in DWDM Networks using Sliceable Bandwidth-Variable Transponders"

- Antonio Napoli, M. M. Mezghanni, D. Rafique, V. A. J. M. Sleiffer, B. Spinnler, M. Bohn: "Novel digital pre-distortion techniques for low-extinction ratio Mach-Zehnder modulators"

- Antonio Napoli, M. M. Mezghanni, D. Rafique, V. A. J. M. Sleiffer, T. Rahman, B. Spinnler, S. Calabro, M. Bohn: "Novel DAC digital pre-emphasis algorithm for next-generation flexible optical transponders"

- A. Dupas, E. Dutisseuil, P. Layec, P. Jennevé, S. Frigerio, Y. Yan, E. Hugues-Salas, G. Zervas, D. Simeonidou, S. Bigo: "Real-Time Demonstration of Software-Defined Elastic Interface for Flexgrid Networks"

- H. Mardoyan, R. Rios-Müller, M. A. Mestre, P. Jennevé, L. Schmalen, A. Ghazisaeidi, P. Tran, S. Bigo, J. Renaudier: "Transmission of Single-Carrier Nyquist-Shaped 1Tb/s Line-Rate Signal over 3000 km"

- A. Morea, A. Lord, D. Verchère: "Cost benefits of asymmetric IP-over-DWDM networks with elastic transceivers"

- A. Asensio, L. M. Contreras, M. Ruiz, V. Lopez, L. Velasco: "Scalability of Telecom Cloud Architectures for Live-TV Distribution"

- J. Barrera, M. Ruiz, L. Velasco: "Orchestrating Virtual Machine Migrations in Telecom Clouds"

- O. González de Dios, R. Casellas, R. Morro, F. Paolucci, V. López, R. Martínez, R. Muñoz, R. Vilalta, P. Castoldi: "First Multi-partner Demonstration of BGP-LS enabled Inter-domain EON control with H-PCE"

- Y. Ou, S. Yan, B. Guo, S. Peng, G. Zervas, R. Nejabati, D. Simeonidou: "Demonstration of Optical Virtualize-able Transceiver using Extended OpenFlow Control"

- Hui Yuan, Miquel Garrich Alabarce, Emilio Hugues-Salas, Georgios Zervas, Dimitra Simeonidou: "Function Placement and Configuration for Power Balanced Network Function Programmable Optical Nodes"

- Adaranijo Peters, Emilio Hugues-Salas, Georgios Zervas, Dimitra Simeonidou: "Measuring Flexibility and Design Tradeoffs of NxM SSS-based ROADMs and BVTs"

- R. Casellas, R. Martínez, R. Muñoz, R. Vilalta, L. Liu: "Multi-domain overarching control of flexi-grid networks with GMPLS as Inter-SDN controller communication"

- R. Martínez, R. Casellas, R. Vilalta, R. Muñoz: "Experimental Assessment of GMPLS/PCE-controlled Multi-Flow Optical Transponders in FlexGrid Networks"

- J. M. Fabrega, M. Svaluto Moreolo, F. J. Vilchez, K. Christodoulopoulos, E. Varvarigos, J. Fernandez-Palacios: "Experimental validation of MTU-BRAS connectivity with DMT transmission and coherent detection in flexgrid metro networks using sliceable transceivers"

European Conference on Networks and Communications (EUCNC 2015), Paris, France, June 29/July 2, 2015

- Ramon Casellas, Filippo Cugini, Ricardo Martinez, Francesco Paolucci, Raul Munoz, Piero Castoldi, and Ricard Vilalta: "Control Plane Solutions for Sliceable Bandwidth Variable Transceivers in Elastic Optical Networks"

- P. Layec, A. Dupas, M. Nölle, J. K. Fischer, C. Schubert, J. M. Fabrega, M. Svaluto Moreolo, N. Sambo, G. Meloni, F. Fresi, A. Napoli, D. Rafique, M. Bohn, A. D'Errico, T. Rahman, E. Hugues-Salas, Y. Yan, S. Yan, G. Zervas, D. Simeonidou, A. Stavdas,

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C.Matrakidis, T. Orphanoudakis: "IDEALIST data plane solutions for elastic optical networks"

- E. Riccardi, A. Pagano, E. Hugues-Salas,G. Zervas, D. Simeonidou, A. D'Errico, M. Bohn, A. Napoli, D. Rafique, N. Sambo, P. Castoldi, T. Rahaman, M. Svaluto Moreolo, J. M. Fabrega, M. Gunkel: "Sliceable bandwidth variable transponder: the IDEALIST vision"

- R. Vilalta, V. López, A. Mayoral, N. Yoshikane, M. Ruffini, D. Siracusa, R. Martínez, T. Szyrkowiec, A. Autenrieth, S. Peng, R. Casellas, R. Nejabati, D. Simeonidou, X. Cao, T. Tsuritani, I. Morita, J. P. Fernández-Palacios, R. Muñoz: "The Need for a Control Orchestration Protocol in Research Projects on Optical Networking"

17th International Conference on Transparent Optical Networks (ICTON 2015), Budapest, Hungary, July 5-9, 2015.

- M. Klinkowski, M. Pióro, M. Żotkiewicz, K. Walkowiak, M. Ruiz, and L. Velasco: "Spectrum Allocation Problem in Elastic Optical Networks - a Branch-and-Price Approach"

- António Eira, João Pedro, João Pires, Juan Pedro Fernández-Palacios: "Performance Evaluation of Heuristic and ILP-Based Algorithms for Multi-Period Planning of SBVT-Enabled Transport Networks"

- João Pedro, Bodhisattwa Gangopadhyay: "Prospects for Transparent Handover between the Metro and Core Segments of Next-Generation Transport Networks"

- João Pedro, Sílvia Pato: "On Scaling Transport Networks for Very High Nodal Degree ROADM Nodes Using State-of-the-Art Optical Switch Technology"

- J.M. Fabrega, L. Martín, M. Svaluto Moreolo: "Data Plane Alternatives based on Sliceable Transceivers for Optical Aggregation Networks"

European Conference on Optical Communications (ECOC 2015), Valencia, Spain, September 27 – October 1, 2015.

- M. Dallaglio, N. Sambo, A. Pagano, E. Riccardi, A. Giorgetti, P. Castoldi: "On the Add & Drop architecture for S-BVTs in EONs"

- A. Sgambelluri, A. Giorgetti, F. Paolucci, F. Cugini, P. Castoldi: "Experimental Demonstration of Multi-domain Segment Routing"

- M. Imran, F. Paolucci, F. Cugini, A. D'Errico, L. Giorgi, T. Sasaki, P. Castoldi, L. Potì: "Quasi-hitless Software-Defined Defragmentation in Space Division Multiplexing (SDM)"

- F. Cugini, F. Fresi, F. Paolucci, G. Meloni, L. Potì, N. Sambo, A. D'Errico, P. Castoldi: "Towards Plug-and-Play Software-defined EONs: Field Trial of Self-Adaptation Carrier Spacing"

- A. Ehrhardt, W. Weiershausen, M. Gunkel, A. Mattheus: „High-Speed Networks in Field Operation: an Operator's View"

- C. Behrens, M. Gunkel, W. Weiershausen, A. Gladisch: „Adaptive Transceivers: Does the operator benefit?"

- P. Layec, C. Dorize, S. Bigo: "Multiflow regeneration using network coding for bidirectional links"

- Pablo Wilke Berenguer, Talha Rahman, Antonio Napoli, Markus Nölle, Colja Schubert, Johannes Karl Fischer: "Nonlinear Digital Pre-Distortion of Transmitter Components"

- A. Asensio, M. Ruiz, L.M. Contreras, L. Velasco, and G. Junyent: "Dynamic Customer Virtual Network Reconfiguration with QoS Constraints and Bandwidth Guarantees"

- Ll. Gifre , R . Martínez , R . Casellas , R. Vilalta , R. Muñoz , and L. Velasco: "Modulation Format - aware Re - Optimization in Flexgrid Optical Networks : Concept and Experimental Assessment"

- A. Castro , Ll. Gifre , C. Chen , J. Yin , Z. Zhu , L. Velasco , S. J. B. Yoo: "Experimental Demonstration of Brokered Orchestration for end-to-end Service Provisioning and Interoperability across Heterogeneous Multi-Operator (Multi-AS) Optical Networks"

- Adrian Farrel: "An Architecture, Protocols, and Information Models for SDN in Flexi-Grid Optical Networks"

- A. Peters, E. Hugues-Salas, G. Zervas, D. Simeonidou: "Design of Elastic Optical Nodes based on Subsystem Flexibility Measurement and other Figures of Merit"

- O. González de Dios, R. Casellas, F. Paolucci, A. Napoli, L. Gifre, S. Annoni, S. Belotti, U. Feiste, D. Rafique, M. Bohn, S. Bigo, A. Dupas, E. Dutisseuil, F. Fresi, B. Guo, E. Hugues, P. Layec, V. López, G. Meloni, S. Misto, R. Morro, T. Rahman, G. Khanna, R. Martínez, R. Vilalta, F. Cugini, L. Poti, R. Muñoz, Y. Shu, S. Yan, Y. Yan, G. Zervas, R. Nejabati, D. simeonidou, L. Velasco, A. D'Errico: "First Demonstration of Multi-vendor and Multi-domain EON with S-BVT and Control Interoperability over Pan-European Testbed"

- R. Casellas, R. Muñoz, R. Vilalta, R. Martínez: "Inter DC orchestration solutions and overarching control: towards a 5G integration"

- A. Mayoral, R. Vilalta, R. Casellas, R. Muñoz, R. Martínez: "Traffic Engineering enforcement in multi-domain SDN orchestration of Multi-Layer (packet/optical) networks"

1.4 Printed Publications in Magazines and Journals

The dissemination of IDEALIST project results comprised contributions to scientific publications; the goal was to publish the new, original results in journals/magazines of high impact factor in the areas of optical communications and networking, comprising but not limiting to:

- OSA Optics Express

- IEEE/OSA Journal of Lightwave Technology (JLT)

- IEEE/OSA Journal of Optical Communications and Networking (JOCN)

- IEEE Communications Letters

- IEEE Communications Magazine

- IEEE Network - The Magazine of Global Internetworking

- Elsevier Computers Networks

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- Elsevier Optical Switching and Networking

- Springer Photonic Network Communications

A significant amount of high-impact publications demonstrated unambiguously and rigorously the scientific quality of the project and globally informed research peers about the results of this project.

Amongst others, the following significant contributions were published by the partner of the IDEALIST project:

IEEE Communications Magazine

- Nicola Sambo, Piero Castoldi, Antonio D'Errico, Emilio Riccardi, Annachiara Pagano, Michela Svaluto Moreolo, Josep M. Fàbrega, Danish Rafique, Antonio Napoli, Silvano Frigerio, Emilio Hugues Salas, Georgios Zervas, Markus Nölle, Johannes K. Fischer, Andrew Lord, and Juan P.F.-P Gimenez: "Next Generation Sliceable Bandwidth Variable Transponders" in IEEE Communications Magazine 2015.

  o Abstract: This article reports the work on next genera- tion transponders for optical networks carried out within the last few years. A general architecture supporting super-channels (i.e., optical connections composed of several adjacent subcarriers) and sliceability (i.e., subcarriers grouped in a number of independent super-channels with different destinations) is presented. Several transponder implementations supporting different transmission techniques are considered, highlighting advantages, economics, and complexity. Discussions include electronics, optical components, integration, and programmability. Application use cases are reported.

- D. Klonidis, F. Cugini, O. Gerstel, M. Jinno, V. Lopez, E. Palkopoulou, M. Sekiya, D. Siracusa, G. Thouénon, C. Betoule: "Spectrally and Spatially Flexible Optical Network Planning and Operations" in IEEE Communications Magazine 2015.

  o Abstract: The advent of spectrally flexible (a.k.a. elastic) optical networking is widely identified as the next generation optical network solution that permits varying bandwidth demands to be dynamically assigned over flexible spectral containers, targeting optimum use of the available network resources. Additionally, the adoption of the space dimension is identified as a promising solution for the capacity expansion of future networks, while novel spatial-spectral switching solutions show that the flexible networking concept can be further expanded over both the spatial and spectral dimensions. This article provides an overview of the latest developments and possible approaches with respect to flexible optical networking and the emerging benefits that spatially flexible networking approaches can offer. The focus is on the network planning and resource optimization functions, the main network operations related to fragmentation and IP/optical layer integration, and the control plane solutions.

- Emilio Hugues-Salas, Georgios Zervas, Dimitra Simeonidou, Evangelos Kosmatos, Theofanis Orphanoudakis, Alexandros Stavdas, Marc Bohn, Antonio Napoli, Talha Rahman, Filippo Cugini, Nicola Sambo, Silvano Frigerio, Antonio D'Errico, Annachiara Pagano, Emilio Riccardi, Victor López, and Juan Pedro Fernández-

Palacios Giménez: "Next Generation Optical Nodes: The Vision of the European Research Project IDEALIST" in IEEE Communications Magazine 2015.

- o As traffic demands become more uncertain and newer services continuously arise, novel network elements are needed to provide more flexibility, scalability, resilience and adaptability to today's optical networks. Considering these requirements, within the European project IDEALIST the investigation of elastic optical networks is undertaken with special focus on next generation optical node architectures. As an evolution of existent ROADMs and OXCs, these optical nodes will establish a new paradigm in which the network requirements will be efficiently addressed considering various emerging dimensions. In this article, we describe the drivers, architectures, and technologies that will enable these novel optical nodes. In addition, multivendor traffic interoperability, optical defragmentation, and node cascadability are also described as considerations in the node design.

- Luis Velasco, Luis Miguel Contreras, Giuseppe Ferraris, Alexandros Stavdas, Filippo Cugini, Manfred Wiegand, and Juan Pedro Fernández-Palacios: "A Service-Oriented Hybrid Access Network and Clouds Architecture" in IEEE Communications Magazine 2015.

- o Many telecom operators are deploying their own cloud infrastructure with the two-fold objective of providing cloud services to their customers and enabling network function virtualization. In this article we present an architecture we call SHINE, which focuses on orchestrating cloud with heterogeneous access and core networks. In this architecture intra and inter DC connectivity is dynamically controlled, maximizing the overall performance in terms of throughput and latency while minimizing total costs. The main building blocks are: a future-proof network architecture that can scale to offer potentially unlimited bandwidth based on an active remote node (ARN) to interface end-users and the core network; an innovative distributed DC architecture consisting of micro-DCs placed in selected core locations to accelerate content delivery, reducing core network traffic, and ensuring very low latency; and dynamic orchestration of the distributed DC and access and core network seg- ments. SHINE will provide unprecedented quali- ty of experience, greatly reducing costs by coordinating network and cloud and facilitating service chaining by virtualizing network functions.

OSA/IEEE Journal of Optical Communications and Networking

- M. Żotkiewicz, M. Ruiz, M. Klinkowski, M. Pióro, and L. Velasco: "Reoptimization of Dynamic Flexgrid Optical Networks After Link Failure Repairs" in OSA/IEEE Journal of Optical Communications and Networking 2015.

- P. Wright, M. C. Parker, A. Lord: "Minimum- and Maximum-Entropy Routing and Spectrum Assignment for Flexgrid Elastic Optical Networking" in OSA/IEEE Journal of Optical Communications and Networking 2015.

- F. Cugini, F. Fresi, F. Paolucci, G. Meloni, N. Sambo, A. Giorgetti, T. Foggi, L. Potí, and P. Castoldi: "Active Stateful PCE With Hitless LDPC Code Adaptation" in OSA/IEEE Journal of Optical Communications and Networking 2015.

- Alessio Giorgetti, Francesco Paolucci, Filippo Cugini, and Piero Castoldi: "Dynamic Restoration With GMPLS and SDN Control Plane in Elastic Optical Networks" in OSA/IEEE Journal of Optical Communications and Networking 2015.

- F. Paolucci, F. Cugini, F. Fresi, G. Meloni, A. Giorgetti, N. Sambo, L. Potí, A. Castro, L. Velasco, and P. Castoldi: "Superfilter Technique in SDN-Controlled Elastic Optical Networks" in OSA/IEEE Journal of Optical Communications and Networking 2015.

- António Eira, João Pedro, João Pires: "Optimal Multi-Period Provisioning of Fixed and Flex-Rate Modular Line Interfaces in DWDM Networks" in OSA/IEEE Journal of Optical Communications and Networking 2015.

- M. Ruiz and L. Velasco: "Serving Multicast Requests on Single Layer and Multilayer Flexgrid Networks" in OSA/IEEE Journal of Optical Communications and Networking 2015.

- O. González de Dios, R. Casellas, R. Morro, F. Paolucci, V. López, R. Martínez, R. Muñoz, R. Vilalta: "Multi-partner Demonstration of BGPLS enabled multi-domain EON control and instantiation with H-PCE" in OSA/IEEE Journal of Optical Communications and Networking, OFC2015 Special Issue, Vol. 7, No. 11, 2015.

- R. Casellas, R. Martínez, R. Muñoz, R. Vilalta, L. Liu: "Control and Orchestration of Multidomain Optical Networks With GMPLS as Inter-SDN Controller Communication" in OSA/IEEE Journal of Optical Communications and Networking, OFC2015 Special Issue, Vol. 7, No. 11, 2015.

- Miquel Garrich, Norberto Amaya, Georgios S. Zervas, Juliano R. F. Oliveira, Paolo Giaccone, Andrea Bianco, Dimitra Simeonidou, and Júlio César R. F. Oliveira: "Architecture on Demand Design for High- Capacity Optical SDM/TDM/FDM Switching" in OSA/IEEE Journal of Optical Communications and Networking 2015.

- A. Mayoral, V. López, O. González de Dios, J. P. Fernández-Palacios: "Migration Steps Toward Flexi-Grid Networks" in OSA/IEEE Journal of Optical Communications and Networking 2015.

- Ricardo Martínez, Ramon Casellas, Ricard Vilalta and Raul Muñoz: "GMPLS/PCE-controlled Multi-Flow Optical Transponders in Elastic Optical Networks", in OSA/IEEE Journal of Optical Communications and Networking, OFC2015 Special Issue, Vol. 7, No. 11, 2015.

- Nicola Sambo, Francesco Paolucci, Gianluca Meloni, Francesco Fresi, Luca Potì, and Piero Castoldi: "Control of Frequency Conversion and Defragmentation for Super-Channels" in OSA/IEEE Journal of Optical Communications and Networking 2015.

- Matthias Gunkel, Arnold Mattheus, Josef Röse, Felix Wissel, Antonio Napoli, João Pedro, Nelson Costa, Talha Rahman, Gianluca Meloni, Francesco Fresi, Filippo Cugini, Nicola Sambo, and Marc Bohn: "Vendor-Interoperable Elastic Optical Interfaces – standards, experiments and challenges" in OSA/IEEE Journal of Optical Communications and Networking 2015.

OSA/IEEE Journal of Lightwave Technology

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- Lluis Gifre, Francesco Paolucci, Oscar Gonz´alez de Dios, Luis Velasco, Luis Miguel Contreras, Filippo Cugini, Piero Castoldi, and Vıctor Lopez: "Experimental Assessment of ABNO-Driven Multicast Connectivity in Flexgrid Networks" in IEEE/OSA Journal of Lightwave Technology, 2015

- P. Layec, A. Ghazisaeidi, G. Charlet, J.-C. Antona, S. Bigo: "Generalized Maximum Likelihood for Cross-Polarization Modulation Effects Compensation", in IEEE/OSA Journal of Lightwave Technology, 2015

- L. Liu, W. Peng, R. Casellas, T. Tsuritani, I. Morita, R. Martínez, R. Muñoz, M. Suzuki, S.J. Ben Yoo: "Dynamic OpenFlow-based Lightpath Restoration in Elastic Optical Networks on the GENI Testbed" in IEEE/OSA Journal of Lightwave Technology, Vol. PP, No. 99, 2015.

- R. Casellas, R. Muñoz, R. Martínez, R. Vilalta, A. Mayoral, L. Liu, T. Tsuritani, I. Morita: "Overarching Control of Flexi Grid Optical Networks: Interworking of GMPLS and OpenFlow Domains" in IEEE/OSA Journal of Lightwave Technology, Vol. 33, No. 5, pp. 1054-1062, March 2015.

- Sambo, N.; Meloni, G. ; Cugini, F. ; D'Errico, A. ; Poti, L. ; Iovanna, P. ; Castoldi, P.: " Routing Code and Spectrum Assignment (RCSA) in Elastic Optical Networks" in IEEE/OSA Journal of Lightwave Technology, 2015

- A. Sgambelluri, F. Paolucci, A. Giorgetti, F. Cugini, P. Castoldi: "Experimental Demonstration of Segment Routing" in IEEE/OSA Journal of Lightwave Technology, 2015

Springer Photonic Network Communications

- Adrian Asensio, Marc Ruiz, Luis Velasco:" Orchestrating connectivity services to support elastic operations in datacenter federations" in Springer Photonic Network Communications, vol. 29, pp. 291-306, 2015

Elsevier Optics Communications

- J. M. Fabrega, P. Sevillano, M. Svaluto Moreolo, A. Villafranca, F. J. Vilchez, J. M. Subías: "OFDM subcarrier monitoring using high resolution optical spectrum analysis", in Elsevier Optics Communications, Vol. 342, pp. 144-151, May 2015

1.5 Project Newsletter

The newsletter is a collaborative outcome of a joint activity with reduced scientific focus, accessible to the general public. It highlights what is going on inside the project and points out our global vision on elastic networking. It reveals the work package structure, presents the economic justification of elastic networking and introduces next migration steps towards an appropriate network architecture.

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Figure 2: Snapshot of the second newsletter's cover page

For downloading, visit the website or follow this link:

http://www.ict-idealist.eu/index.php/presscorner-newsletters/finish/19-newsletters/376-newsletter-idealist-n-2

1.6 Book

The Idealist consortium is about to publish a book on "**Elastic Optical Networks: Architectures, Technologies, and Control**"

Editors: Victor López and Luis Velasco

In this book we present:

a) The evolution from WDM to flexible or elastic optical networks (EON) and the new applications that EONs can support. Planning and algorithms for EONs will be presented, including mathematical models and algorithms.

b) In the data plane, transmission in EON will cover next generation of bandwidth variable transponders, novel modulation formats, mitigation of impairments, and node architectures.

c) In the control plane, extensions to GMPLS and OpenFlow for EONs will be presented and the concept of in-operation planning introduced.

The book will be the first to comprehensively address all these topics. It aims at representing a reference manual in the coming years for researchers, engineers, and practitioners working in the field.

UNIT I - NETWORK ARCHITECTURE AND PLANNING

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- Evolution from wavelength switch to flexgrid optical networks (Andrew Lord)
- Taking advantage of elastic optical networks (Alexandros Stavdas)
- Solving routing and spectrum allocation related optimization problems (Luis Velasco)

UNIT II – DATA PLANE
- Transmission in elastic optical networks (Antonio Napoli)
- Node architecture (George Zervas)
- Sliceable Bandwidth Variable Transponders (Juan Pedro Fernandez-Palacios)

UNIT III – CONTROL PLANE
- Control plane architecture (Oscar González de Dios)
- OpenFlow in optical networks (Filippo Cugini)
- Application Based Network Operations (Daniel King)
- In-operation Planning. Architecture and Use cases (Ramon Casellas)

The audience of this book will be:

a. Students and researchers in the field of technologies for optical communications, including network architectures and planning, data plane, and control and management planes (all these topics are expected to attract lot of attention in the next years).

b. CTOs, network architecture Officers, Strategy Officers, etc looking at migrating or deploying flexgrid in their core networks.

c. Engineers and practitioners working for telecom network operators, service providers, and vendors that will expect to gain knowledge on a rapidly evolving topic and that need a single comprehensive reference that covers the multiple aspects of EONs.

The book is accepted to be published in the Springer Optical Network series and royalties will be donated to a non-profit organization (e.g., Doctors without frontiers).

1.7 IDEALIST Workshops

IDEALIST organized two workshops at ECOC 2015 in collaboration with DISCUS and STRAUSS projects

WS – Fibre access and core network evolution: what are the next steps towards an integrated end-to-end network?

Organizers

Juan Pedro Fernández-Palacios Telefónica I+D, Spain-IDEALIST

Michela Svaluto Moreolo CTTC, Spain-STRAUSS

Marco Ruffini Trinity College Dublin, Ireland-DISCUS

Abstract:

While FTTH is widely recognized as the ultimate goal of access network upgrade, the path towards its realization seems to differ among network operators, some of them planning direct FTTH deployment, while others considering intermediate steps such as FTTCab or FTTCurb. In addition, due to the large increase in available bandwidth that new access technologies will bring, it becomes of paramount importance to understand how the network core should evolve to support such increase in user bandwidth. Recent studies point at end-to-end solutions, based on seamless integration of access and core as a means to develop architectures that are sustainable from a cost and energy consumption perspective, while providing the necessary capacity and flexibility to support forthcoming services and applications.

This workshop will provide a discussion on the access, core evolution and end-to-end network architecture with two main objectives. The former is to identify the drivers for the different operators, pushing them towards different evolution plans both in the access and core development. The latter is to understand which are the current plans for network upgrading and towards a tighter integration of access and core networks, as well as which are the challenges and potential solutions for evolution towards next-generation architectures.

A main outcome of the workshop will be also to get an idea of the rationale behind the choices from different operators and vendors, whether there are common issues, misconceptions, etc.

Speakers/Talks:

- Ari Sorsaniemi DG CONNECT, European Commission, Belgium

  Challenges for development of fast broadband, EU targets, digital divide and regulatory perspectives

- David Payne Trinity College Dublin, Ireland & Aston University, UK

  Introduction to end-to-end design principle and presentation of cost modeling studies

- Andrew Lord BT, UK – Juan Fernández-Palacios Telefónica I+D, Spain

  Optimization opportunities by integrating optical access transport planning. Control and data plane interoperability in Elastic Optical Networks

- Bruno Cornaglia Vodafone, Italy

  Virtualisation for a multi-service network as enabler for future convergence of access networks

- Thomas Pfeiffer Alcatel Lucent Germany

  Technical challenges for next generation TWDM-PONs and on access network convergence

- Dimitra Simeonidou University of Bristol, UK

  Bristol Is Open: A city infrastructure pioneering SDN and flexible/programmable optical technology enablers for future end-to-end smart city services

- Jens Rasmussen Fujitsu Laboratories Ltd., Japan

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How to face the emerging high capacity demand with cost, size and power efficient technologies.

- Naoya Wada NICT, Japan
  Technologies and system solutions for enabling an integrated end-to-end network

WS – SDN & NFV: Real value with new business opportunities or research hype with unmanageable complexity?

Organizers

Achim Autenrieth ADVA Optical Networking, Germany- STRAUSS

Andrea Di Giglio Telecom Italia, Italy- DISCUS

Daniel King Old Dog Consulting, UK- IDEALIST

Abstract:

Network programmability based on Software-Defined Networks (SDN) and Network Function Virtualization (NFV) is a major trend in optical network research and standardization. After the initial focus on the OpenFlow protocol as a new southbound interface to directly control the forwarding plane of packet switches, SDN is gaining increased importance as new networking paradigm allowing virtualization and programmability based on hardware abstraction and open programming interfaces. New SDN architectures and protocols are being proposed and discussed in the IETF, e.g. northbound protocols for topology dissemination and service orchestration. NFV is increasing the flexibility even further by moving network functions from dedicated hardware to virtual machines. This new degrees of flexibility pose opens a set of new challenges and research issues, ranging from service orchestration, security, reliability, monitorability, etc.

The open questions is, if and how SDN and NFV can simplify the way optical access and core network are operated.

This workshop will bring together views from ongoing research projects (e.g., STRAUSS, IDEALIST, DISCUS, COMBO) as well as Industrial actors (both network operators and vendors) on hot topics and current trends in SDN and NFV. The topics will be presented in the form of invited talks of 15 minutes. A moderated panel discussion both for research and industrial will deal with the controversial topics that can be also discussed together with the audience.

Speakers/Talks:

- Ricard Vilalta CTTC, Spain.
  SDN orchestration of multi-domain and multi-vendor transport networks
- Adrian Farrel Old Dog Consulting, UK
  An Architecture, Protocols and Information Models for SDN in FlexGrid Optical Networks
- Victor Lopez Telefónica, Spain

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SDN & NFV for Distributed Core seamlessly integrating wireless and fixed optical network

- Stephan Pachnicke ADVA Optical Networking, Germany
  NFV-based Universal Access for converged fixed and mobile broadband access/aggregation networks
- Francesco Paolucci SSSUP, Italy
  Path determination as a key component of SDN and NFV for Access, Core, Transport and IoT
- Takehiro Tsuritani KDDI R&D Labs, Japan
  SDN and NFV – Views from Japanese Operator
- Gabriele Maria Galimberti Cisco Systems, Italy
  From Transport SDN to multilayer SDN
- Vinayak Dangui Google, USA
  SDN-based Scalable Optical Network Management – A case for OpenConfig YANG Models
- Ming Xia Ericsson Research Silicon Valley, USA
  SDN-based performance monitoring for virtual Network Function (vNF) service chaining
- Dirk Van Den Borne Juniper Networks, Germany
  Multi-layer SDN with YANG Data Model for TE Topologies

1.8 IDEALIST integrated demonstration

IDEALIST integrated testbed demonstration was presented at the ECOC 2015 workshop on "Fibre access and core network evolution".

IDEALIST demonstrated for the first time a fully end-to-end interoperable EON network at control and data plane level.

The testbed, shown in fig. 3, is built by the interconnection of different components, both hardware and software, physically distributed within labs in Madrid, Barcelona, Bristol, Pisa, Torino, Vimercate, Paris and Munich. The testbed encompasses three Flexi-grid

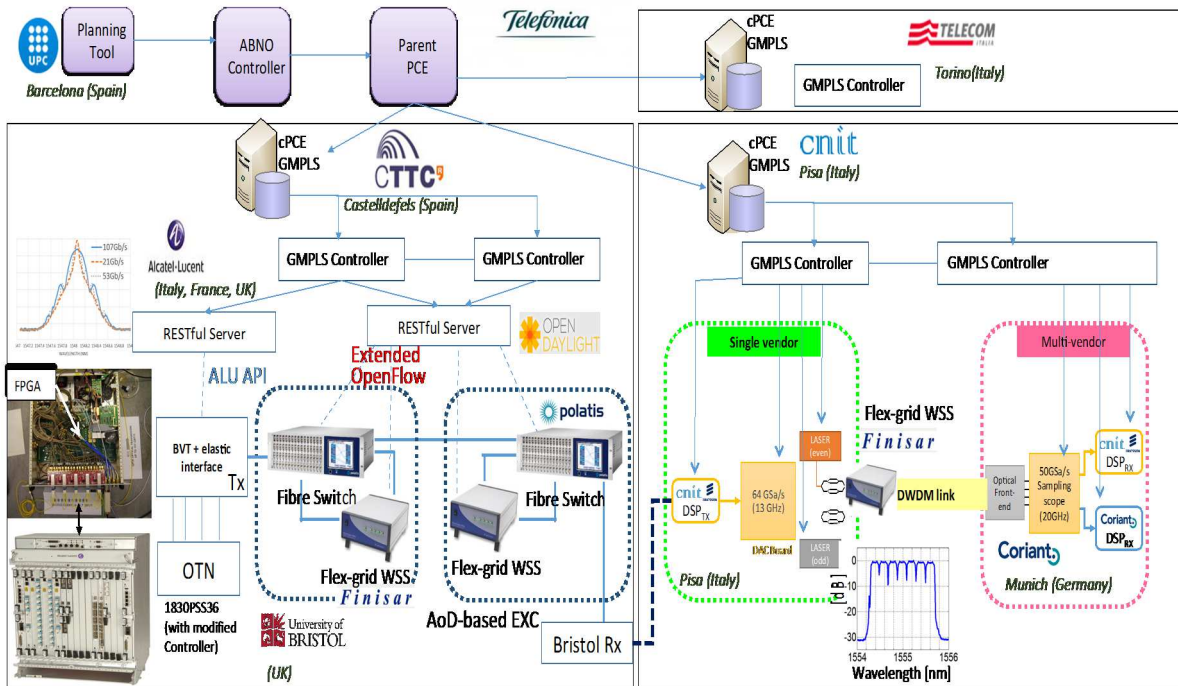domains with different capabilities, one hierarchical PCE, an ABNO Controller and the PLATON planning tool.

Figure 3: IDEALIST multi-partner testbed

A recorded video demonstration is available at IDEALSIT website.

A detailed description of this demonstration was also included in the **IDEALIST ECOC 2015 post-deadline paper**: "First Demonstration of Multi-vendor and Multi-domain EON with S-BVT and Control Interoperability over Pan-European Testbed". O. Gonzalez de Dios et al.

1.9 Further Dissemination Events

This section summarizes all relevant further dissemination events not yet mentioned in the document.

1.9.1.1 Further Dissemination activities per Partner

ALBLF

- We showcased a demonstration based on elastic aggregation and bandwidth variable transponder during the Bell Labs FutureX days in Nozay (Paris area) in June 2015. These were 2 days during which we exposed our SDN-controlled elastic interface prototype and our setup of flexgrid restoration in front of Alcatel-Lucent's clients and partners. This year the audience was mostly a French audience.

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- We have filed several patents on elastic optical spectrum management

Deutsche Telekom

- Submission of an invention on "Utilization scenarios for flex-rate interface in aggregation networks" at the European Patent Office (EPA) with the application for a corresponding patent.

BT

- We have filed several patents around the concept of entropy based routing.
- We have provided an end-to-end network demonstration at a large BT Innovation Week in September 2015, with SDN orchestration and other Idealist concepts.

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**Standardization and
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2. Standardisation Objectives, Proposals, Status and Next Steps

This section provides summary of the IDEALIST Standards Development Organizations (SDO) results. These results are broken down into objectives, contributions, current status and next steps.

This document is split into two distinct into results for two SDO areas:

- IETF
- ITU-T

According to the plan for dissemination and standardization activities as prepared and described in "IDEALIST D6.1: Dissemination & Standardisation Plan" (April 30, 2013) where apart from other dissemination related topics the Standard Development Organizations (SDOs) were identified, we pursued the following activities:

Control plane functions include: topology management, path computation or signaling are distributed via a set of routing and signaling protocols. The protocols ensure the coordination and synchronization functions and recover from failures, autonomously. Typically, the provisioning of a new service is done upon request from a separate system, such as an NMS or SDN Controller.

The IDEALIST reference architecture was defined by the ITU-T, specifically around a framework entitled Automatically Switched Optical Network, or ASON for short. ASON provides an enabling set of technologies for dynamic control of an optical network, automating the resource and connection management. ASON relies of the Generalized Multiprotocol Label Switching (GMPLS) set of protocols defined by the IETF.

Control plane standardization has been a key objective for the IDEALIST project. When we started the project we understood that EONs and flexi-grid would provide an exciting opportunity for showcasing European research, but we were also eager to demonstrate industry impact as well.

Three years since the IDEALIST project began we are able to show that our research effort has yielded multiple International Standards and we have achieved significant success and leadership at multiple Standards Development Organizations (SDOs), and across multiple work areas.

The ITU-T and Internet Engineering Task Force (IETF) are two of the most important SDOs related to telecommunications and are populated with large international communities of network designers, operators, and vendors. All concerned with the specification, development and evolution of the Internet architecture and especially in the case of the IETF, the smooth operation of the Internet.

Our SDO control plane and SDN achievements include:

ITU-T

- Leading technical clarifications for standardization of data plane technologies related to flexi-grid

IETF

- Multiple RFCs related to Control Plane signaling and resource management

- Multiple RFCs related to the Path Computation Element

2.1 ITU-T

The IDEALIST effort has been influenced and evolved based on the following ITU-T data plane efforts:

- ITU-T Recommendation G.671: Transmission characteristics of optical components and subsystems" (2009).

- ITU-T Recommendation G.694.1 (revision 2): Spectral grids for WDM applications: DWDM frequency grid" (February 2012).

- ITU-T Recommendation G.694.2: Spectral grids for WDM applications: CWDM wavelength grid"(December 2003).

Previous discussions and contributions within ITU-T SG15 Q6 has been focused on the label aspects of the flexi-grid effort.

TEI standardization plan is focused on ITU-T SG 15 activities in standardizing architectures of optical transport networks, taking into account their technological feasibility and operability.

The participation has been concentrated in Question 6 tasks where specifications are defined for physical layer interfaces of WDM systems, including the OTN, to enable the evolution of long distance networks to support the ubiquitous availability of next-generation high-bandwidth services.

It was important to ensure that these specifications should also enable transverse compatibility in a multi-vendor, multi-network-operator environment. The main target related with IDEALIST running activities for standardization is the insertion of the SuperChannel generation with Time-Frequency Packing technique in the Supplement 39 to ITU-T G-series.

In order to progress our control plane work (especially in the IETF and Internet Draft "Framework and Requirements for GMPLS based control of Flexi-grid DWDM networks") and subsequent solution documents within the IETF CCAMP working group, we also had to send and receive Liaisons between the ITU-T and IETF, to discuss and agree how to progress a wide range of flexi-grid topics that required ITU-T expert opinions. The key technical discussions include:

- Future changes regarding the values of nominal central frequency (NCF) granularity [NCFG, currently 6.25 GHz] and slot width granularity [currently 12.5 GHz], as defined in G.694.1

- Consideration of alternative values (e.g. 3.125 GHz) for NCFG in the foreseeable future

- Clarification on the maximum values of the slot width (m parameter) and the expected use cases (e.g. to cover the whole C band)

- Clarification on the data plane "hitless" and "hitless" capabilities.

- Hitless procedure, such as resizing / restoration of a network media channel (in terms of its frequency slot)

- Examples of cases where hitless capabilities may be considered

- Clarification on the case where an OTUCn is carried by a (co-routed) group of network media channels which must be managed as a single entity (including set up, recovery, and hardware cross-connection)

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Overtime these open issues were clarified by the ITU-T study groups and addressed in corresponding IETF Internet-drafts.

The IDEALIST ITU-T efforts have been led by the IDEALIST partners Ericsson and Telecom Italia, with support from Old Dog Consulting and other IDEALIST partners.

2.2 IETF

Participation in the IETF has been a key objective of the IDEALIST Project. The main mode of participation is via mailing lists: there is one mailing list for each working group where all topics relevant to the working group are discussed. IDEALIST Partners have also attended a number of the IETF meetings

The working groups proceed by developing documents that will be progressed towards becoming standards, or as informational or experimental records. All work in progress and all published documents are freely downloadable from the IETF web site.

An RFC is authored by IETF participants, typically engineers from vendors or network operators, researchers or scientists in the form of a document describing methods, behaviors, research, or innovations. They take many forms: requirements, architecture, protocol specifications, and best practices. All are applicable to the working of the Internet and Internet-connected systems. Each proposal is submitted either for review by a working group tasked with a specific technology topic or challenge, or simply to convey new concepts, information. The IETF adopts some of the proposals published as RFCs as Internet Standards.

2.2.1 Common Control and Measurement Plane (CCAMP) Working Group

The CCAMP working group is responsible for standardizing control plane and management plane for forwarding technologies that are not packet specific, typically found in operator and service provider environments. The CCAMP Charter may be found at:

https://datatracker.ietf.org/wg/ccamp/charter/

Examples of the technologies within the sphere of CCAMP responsibility, include: photonic cross-connects, OEO switches, ROADMs, TDM switches, microwave links, and Ethernet switches. Therefore, to ensure industry deployment and interoperability of Flexi-Grid technologies, this would require extensions to existing control plane technologies.

The documents lead by the IDEALIST partners include three core flexi-grid documents:

- Framework and Requirements for GMPLS-based control of Flexi-grid DWDM [1]

- Generalized Labels for the Flexi-Grid in Lambda Switch Capable (LSC) Label Switching [2]

- RSVP-TE Signaling Extensions in support of Flexible Grid [3]

Are either currently an RFC (principal standards setting technical publication) or a few weeks from publication as RFCs, with a forth document:

- GMPLS OSPF-TE Extensions in support of Flexi-grid DWDM [4]

Being progressed after a recent working group last call (one of the few final steps before publication as an RFC).

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In addition to the flexi-grid framework, routing extensions and signaling extensions standards we have also embarked on new standards for modeling flexi-grid networks. Our models are being developed in YANG, and will be used to model configuration and state data, vital functions for operating networks in commercial environments.

2.2.2 Path Computation Element (PCE) Working Group

The PCE Working Group is chartered to specify the required protocols so as to enable a Path Computation Element (PCE)-based architecture for the computation of paths for MPLS and GMPLS Point to Point and Point to Multi-point Traffic Engineered LSPs. The PCE Charter may be found at:

https://datatracker.ietf.org/wg/pce/charter/

The PCE was integral to the Adaptive Network Manager (ANM) platform and we created a document to identify the technology gaps for further development and deployment of the PCE for industry applications. This became "Unanswered Questions in the Path Computation Element Architecture" and was pubslied as RFC7399 (https://tools.ietf.org/html/rfc7399).

2.2.3 Software Defined Network Research Group

The Software Defined Networking Research Group (SDNRG) investigates SDN from various perspectives with the goal of identifying the approaches that can be defined, deployed and used in the near term as well identifying future research challenges. In particular, key areas of interest include solution scalability, abstractions, and programming languages and paradigms particularly useful in the context of SDN. In addition, it is an explicit goal of the SDNRG to provide a forum for researchers to investigate key and interesting problems in the Software-Defined Networking field.

Finally, the SDNRG provides objective definitions, metrics and background research with the goal of providing this information as input to protocol, network, and service design to SDOs and other standards producing organizations such as the IETF, ETSI, ATIS, ITU-T, IEEE, ONF, MEF, and DMTF.

We have presented the IDEALIST project in SDN RG and provided an opportunity for other academics with industry ties to discuss our project scope and grand research challenges.

2.2.4 Non-WG IETF Proposals

An SDN Controller framework for network operator environments must combine a number of technology components, mechanisms and procedures, including:

- Policy control of entities and applications for managing requests for network resource information and connections

- Gathering information about the resources available in a network

- Consideration of multi-layer resources, and how these topologies map to underlying network resource

- Handling of path computation requests and responses

- Provisioning and reserving network resources

- Verification of connection and resource setup

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Our overall objective was to develop a control and management architecture of transport networks built using core IETF technologies to facilitate network operators to manage their networks using the core principles of SDN, to allow high-layer applications and clients to request, reconfigure and re-optimize the network resources in near real time, and in response to fluid traffic changes and network failures.

We developed our proposal for an SDN controller framework into an IETF-based framework, architecture and use case document entitled Application-Based Network Operations (ABNO) "A PCE-Based Architecture for Application-Based Network Operations".

2.2.5 Ongoing IETF Strategy

As identified, some of the IETF Internet-Drafts are not currently RFCs. Although the IDEALIST project is due to end shortly, key partners (left by Old Dog Consulting) will still continue to work on the proposals to ensure that they do become RFCs and reinforce the industry impact of IDEALIST and its legacy:

IETF Internet-Drafts to complete as RFCs:

[1]   Framework and Requirements for GMPLS-based control of Flexi-grid DWDM Networks - https://tools.ietf.org/html/draft-ietf-ccamp-flexi-grid-fwk

[2]   Generalized Labels for the Flexi-Grid in Lambda Switch Capable (LSC) Label Switching Routers - https://tools.ietf.org/html/draft-ietf-ccamp-flexigrid-lambda-label-05

[3]   RSVP-TE Signaling Extensions in support of Flexible Grid - https://tools.ietf.org/html/draft-zhang-ccamp-flexible-grid-rsvp-te-ext

[4]   GMPLS OSPF-TE Extensions in support of Flexi-grid DWDM networks - https://tools.ietf.org/html/draft-ietf-ccamp-flexible-grid-ospf-ext

[5]   Unanswered Questions in the Path Computation Element Architecture - https://tools.ietf.org/html/rfc7399

[6]   A PCE-Based Architecture for Application-Based Network Operations - https://tools.ietf.org/html/rfc7491

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Acronyms

ABNO	Application-based network operations
ANM	Adaptive Network Manager
API	Application programming interface
ASIC	Application specific integrated circuit
ASON	Automatically Switched Optical Network
BGP-LS	Border gateway protocol – link state
BVT	Bandwidth variable transponder
CAGR	Compound annual growth rate
CapEx	Capital Expenditure
CMOS	Complementary metal oxide semiconductor
DBA	Dynamic bandwidth allocation
DC	Data Centre
DDoS	Distributed denial of service
DSP	Digital signal processing
DWDM	Dense wavelength division multiplexing
E2E	End-to-end
EBL	Elastic Black Link
EDFA	Erbium doped fibre amplifier
EON	Elastic Optical Networking
EVM	Error vector magnitude
FT	Fixed transponder
FLC	First Level Controller
FPGA	Field Programmable Gate Array
FSC	Fibre switch capable
GMPLS	Generalized multiprotocol label switching
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IP	Internet protocol
ITU	International Telecommunications Union
JIT	Just-in-time
MPLS	Multi-protocol label switching
NMS	Network management system
NPCM	Network Planning and Configuration Management

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LCoS	Liquid Crystal on Silicon
LDPC	Low-density parity-check
LSC	Lambda Switch Capable
LSP	Label switched path
MLR	Multi-layer resilience
NIC	Network interface card
NPT	Network Planning Tool
OAM	Operations, administration, and maintenance
OF	OpenFlow
OIF	Optical Internetworking Forum
ONF	Open Network Foundation
OpEx	Operational Expenditure
OSNR	Optical signal-to-noise ratio
OSPF-TE	Open shortest path first – traffic engineering
OSS	Operational support system
OTN	Optical transport network
OTU	Optical Transport Unit
PCE	Path computation element
PCEP	Path computation element protocol
PDM	Polarisation division multiplexing
PIC	Photonic integrated circuits
PLL	Physical and Link Layer
PMD	Polarisation Mode Dispersion
QAM	Quadrature amplitude modulation
QPSK	Quadrature phase shift keying
ROADM	Reconfigurable Optical Add/Drop Multiplexer
RWA	Routing and Wavelength Assignment
S-BVT	Sliceable bandwidth variable transponder
SDH	Synchronous digital hierarchy
SDM	Space Division Multiplexing
SDN	Software defined networking
SDO	Standards development organization
SLA	Service level agreement
SONET	Synchronous optical networking
SP	Service provider

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SSMF	Standard single-mode fibre
TFP	Time Frequency Packing
TMF	Telemanagement Forum
TLV	Type length value
TP	Transport profile
TSDN	Transport SDN
VOA	Variable Optical Amplitude
WDM	Wavelength division multiplexing
WSON	Wavelength Switching Optical Networking
WSS	Wavelength selective switch

Document History

Version	Date	Authors	Comment
0.1	24/09/2015	Matthias Gunkel	Initial document
0.2	25/10/2015	Daniel King	Standard related parts
0.3	26/10/2015	Matthias Gunkel	Review and publications at conferences & workshops
0.4	27/10/2015	Matthias Gunkel	Review and publications in magazines and journals
0.5	29/10/2015	Juan Fernandez-Palacios	Workshops, ECOC demo and Executive Summary
0.6	12/11/2015	Daniel King	ITU-T contributions
0,7	13/11/2015	Juan Fernandez-Palacios	Reviewed version