REACTION:

RESEARCH AND EXPERIMENTAL ASSESSMENT OF CONTROL PLANE ARCHITECTURES FOR IN-OPERATION FLEXGRID NETWORK RE-OPTIMIZATION

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Abstract—The REACTION project proposes, designs, and validates flexi-grid elastic optical networks enabling software-controlled high-rate transmissions. In this paper, the main project objectives are reported, together with a brief summary on two main REACTION studies.

Index Terms—EON, Flexi-grid, PCE, ABNO, RSA.

I. INTRODUCTION

The continuous increase of users' bandwidth requests, combined with the need to adequately address data center connectivity requirements, i s driving the evolution of ultra-high speed optical networks, enabling transmission rates beyond 100Gb/s. These networks are expected to rely on flexi-grid optical cross-connects, enabling finer granularity and flexibility in the use of the optical spectrum compared to that of the fixed grid. Moreover, a new generation of transponders, called sliceable bandwidth-variable transponders (SBVTs), is expected to provide advanced adaptation capabilities enabling elastic network operations (e.g., modulation format and code adaptation, network de-fragmentation, etc).

The REACTION project aims at investigating the benefits of flexi-grid optical networks, specifically considering advanced provisioning and adaptation capabilities. The project is carried out by three partners, CNIT (Pisa, Italy), the Optical Communications Group (GCO) of the Universitat Politècnica de Catalunya (UPC, Barcelona, Spain) and Telefonica Investigation y Desarollo (TID, Madrid, Spain).

II. REACTION ACTIVITIES

The project investigates the benefits of flexi-grid elastic optical networks by addressing three main networking aspects: enabling data plane technologies, routing and spectrum assignment (RSA) algorithms, and control plane architecture.

These three aspects are investigated through both simulative and experimental studies. A specifically designed OPNET Modeler has been also implemented to reproduce a comprehensive flexi-grid control plane. Moreover, a distributed testbed has been setup to experimentally validate the most effective REACTION solutions.

III. OUTCOMES

To provide a hint of the REACTION outcomes assessing the benefits of the flexi-grid technologies, two specific research studies are here reported. Additional REACTION research outcomes are detailed in [1]-[7].

A. Example of adaptation capability: sliceable functionality

1 shows a network scenario applying the sliceable functionality. A 400Gb/s super-channel composed of four contiguous 100Gb/s sub-carriers is considered. The sub-carriers can be configured either to be co-routed along the same path (1b/c) or, when the sliceable functionality is applied, independently routed along multiple paths (1d). In the latter case, more spectrum resources are required (i.e., four frequency slots of 37.5Ghz rather than a single slot of 100GHz, see 1a).

To exploit the benefits of the sliceable functionality, specific routing strategies have been proposed and evaluated through simulations, showing that provisioning blocking probability can be reduced if the sliceable functionality is properly applied, e.g. when there are no more network resources to accommodate an entire super-channel. Further details and application scenarios (e.g., recovery) can be found in [2].

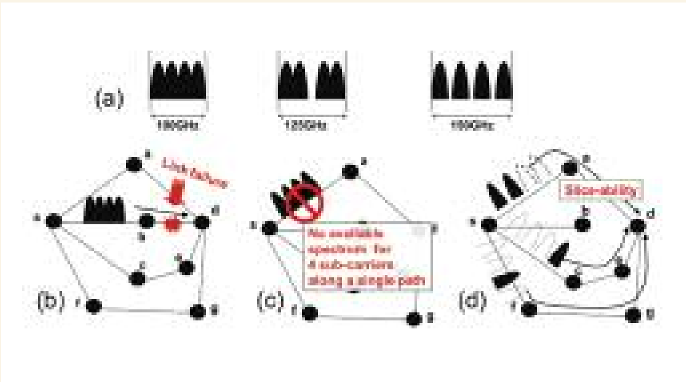

Fig. 1 : Example of sliceable functionality applied to a 4 sub-carrier super-channel in the case of failure recovery.

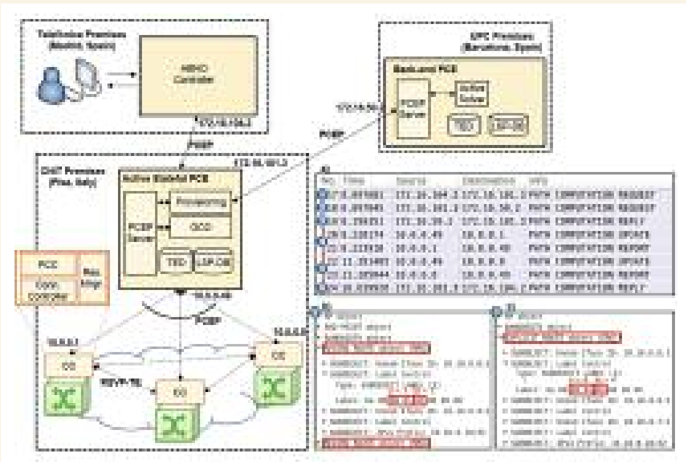

Fig. 2. Distributed field trial set-up and exchanged messages

B. Sliceable functionality in provisioning and recovery

A use case of in-operation network planning is considered. When a link fails, multipath restoration can be used to increase restorability of affected connections at the cost of worse resource utilization and spectral efficiency.

After the link is repaired, the multipath after failure repair optimization (MP-AFRO) problem can be used to aggregate multiple sub-connections serving a single demand using shorter routes, thus releasing spectrum resources that now can be used to convey new connection requests.

The MP-AFRO problem has been addressed within REACTION by proposing a specifically designed mathematical formulation and a heuristic algorithm, successfully providing good feasible solutions in practical computation times.

The algorithm has been experimentally validated on a distributed test-bed connecting premises in Telefonica, CNIT, and UPC. After a link is repaired, network re-optimization is requested from the Network Management System (NMS). The Application-Based Network Operations (ABNO) architecture controls a flexgrid-based optical network, where the Path Computation Element (PCE) architecture consists of a front-end PCE (fPCE) and a back-end PCE (bPCE). The ABNO controller is in charge of initiating the MP-AFRO workflow, requesting re-optimization to the fPCE, which delegates complex computations to the bPCE. The relevant PCE Protocol (PCEP) messages are reported in Fig. 2. The results of the path computation trigger network re-optimizations performed through the Generalized Multi-Protocol Label Switching (GMPLS) protocol suite, extended for flexi-grid optical networks. This way, MP-AFRO is successfully performed.

Further details can be found in [4].

IV. CONCLUSIONS

This paper briefly reported the main REACTION project objectives and activities. Two examples of project achievements are summarized, showing the benefits of flexi-grid technologies due to the introduction of advanced transmission adaptation capabilities, effective RSA algorithms, and innovative control plane architectures.

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