June—November 2013
Issue 1

STRAUSS newsletter

What's going on in STRAUSS?

The kick-off meeting of the STRAUSS project was held in Europe, at CTTC premises in Castelldefels (Barcelona), Spain, on July 22nd and 23rd, 2013. A total of 20 attendees from all the Japanese and European institutions participated in the meeting. A second project meeting was held at ECOC2103 in London (UK), on September 23rd 2013, focused on international EU-Japan testbed collaborations. The results of these international testbed collaborations are expected to be presented at OFC14. The next plenary meeting will be held in Tokyo, Japan, on January 2014.

During the first half year period of the project, approaches to sliceable bandwidth variable transponder (SBVT) design and implementations have been investigated. Also development and deployment of optical packet switching (OPS) / optical circuit switching (OCS) technologies and how they can meet the requirements in different areas of the network have been analysed and discussed. The interface development to cross-connect the two domains of OPS and OCS using high performance FPGA platforms has been other point of the talks. Apart from the studies and discussions, first series of joint experimental activities have been carried out. A cost-effective time-sliceable orthogonal frequency division multiplexing (OFDM) transceiver using low-complex digital signal processing (DSP), intensity modulation (IM) and direct detection (DD) has been experimentally investigated. Slicing capabilities are tested for concurrently serving 12.5GHz channels running up to 10Gb/s variable bandwidth optical routes covering up to 185km.

Initial considerations and research work covering virtualization, control plane and orchestration have also been considered. Concerning virtualization, the initial software visor architecture responsible for virtualizing multi-technology transport nodes and links has been defined, summarizing the state-of-the-art of the virtualization algorithms as well as analyzing their inputs and outputs. This has led to initial algorithm design considerations in terms of functionalities and their implementation and validation. A proof-of-concept of a resource broker to dynamically provision multi-domain virtual optical network (VON) across heterogeneous control (GMPLS, OpenFlow) domains and OPS and elastic optical network (EON) transport technologies has been designed and experimentally evaluated in an international testbed across Spain, UK and Japan. For the control plane and orchestration tasks, the project has proceeded in different areas. First, models for devices to be controlled

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need to be developed, and there has been some investigation of node constraints and impairments. Then notable effort has been done enumerating and studying existing and potential architectures for control and service orchestration. This includes for example, use cases and existing interfaces to export topologies within the scope of the IETF. The applicability of IETF ABNO (Application Based Network Operations) or the PCEP (Path Computation Element Communication Protocol) as frameworks for control orchestration has been stated and, in this sense, there has been a preliminary design, functional specification and development of a stateful hierarchical path computation element (PCE) architecture for orchestrating GMPLS and OpenFlow control planes. Finally, preliminary studies on the integration of data center orchestration with a software defined network (SDN) controlled optical transport networks have been carried out, including the applicability of OpenDayLight, Floodlight and OpenStack, managing for virtual machines and virtual optical transport networks. In particular, the first field demonstration of cloud data center workflow automation employing dynamic optical transport network resources under OpenStack and OpenFlow orchestration has been performed in collaboration with the ICT IDEALIST project. This work was presented as Post-deadline paper at ECOC 2013.

STRAUSS has performed, in collaboration with the IDEALIST project, the first field demonstration of cloud data center workflow automation employing dynamic optical transport network resources under OpenStack and OpenFlow orchestration. This work was presented as Post-deadline paper at ECOC 2013.

2013 ICT Japan-EU project launching event and 12th FP7 concertation meeting

STRAUSS is the first ICT research Project in the field of optical communications between Europe and Japan funded by the EC's FP7, MIC and NICT.

The European Commission (EC), the Japanese Ministry of Internal Affairs and Communications (MIC), and the National Institute of Information and Communications Technology (NICT) have organized an event to launch the six joint projects that were selected through the EU-Japan coordinated call. The six project are: STRAUSS (Optical communications), MiWEBA (Wireless communications), NECOMA (Cybersecurity for improved resilience against cyber threats), ClouT (Extending the cloud paradigm to the Internet of Things), FELIX (Federation of testbeds: Control, tools and experiments), and GreenICN (Green & content centric networks).

This event acknowledged the start of the ICT research projects as the first case for EC and Japan, and the continuous cooperation among EC, MIC and NICT by signing a memorandum. It was held in Tokyo on July 2nd, 2013, and high level representatives of EU and Japan authorities participated. Each project was represented by both the European and Japanese Coordinators, who provided an overview of the projects' objectives, target outcome, organization, etc.

The STRAUSS project has also participated for the first time in the Converged and Optical Networks (CaON) Cluster Meeting and the Future Networks 12th FP7 Plenary Concertation meeting held on October 22nd and 23rd, 2013, in Brussels. The EU Project Coordinator of STRAUSS provided an overview of the project (consortium, motivation, considered architecture, main objectives, work methodology and expected impact) in the CAON cluster meeting.

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Why do we need software-defined flexible optical networks for Ethernet transport?

The adoption of Ethernet as the technology of choice in data centers (both intra- and inter- data center traffic) is a main driver and use case for the development of efficient technologies for the delivery of Ethernet services. Such services can be carried over physical Ethernet networks (e.g. based on 802.1ad and 802.1ah) or other packet transport networks (e.g., IP/MPLS routers or MPLS-TP using Pseudowires) within a data center. The optical transmission and switching technologies provide an unmatched combination of cost- and energy- efficiency as well as high capacity, for long haul networks transporting huge amounts of aggregated data among data centers. DWDM networks supporting Optical Circuit Switching (OCS) provide the underlying infrastructure with low attenuation and almost error-free transmission, and are mature enough for deployment.

Although the combination of OCS and electrical packet switching technologies seems to meet the requirements of the Ethernet transport, major issues need to be addressed and solved for data rates beyond 100 Gbps. In fact, in this case, classical optical spectrum management techniques based on a fixed allocation of optical channels are not sufficient. In order to allow efficient allocation of optical spectral bandwidth, the ITU-T is extending the recommendations [G.694.1] and [G.872] to include the concept of flexible WDM grid: a new DWDM grid has been developed, defining a set of nominal central frequencies, a smaller channel spacing and the concept of "frequency slot" (i.e., a frequency range). A data plane connection is switched based on variable-sized frequency slots, adjusted depending on the requirements of transport tributaries such as data rate, spectral efficiency, quality of service and modulation format. Advanced multi-level modulations provide different degrees of robustness, different spectral efficiency and spectrum occupation, based on varying the symbol rate and bits per symbol by means of digital signal processing (DSP). Optical multicarrier techniques are suitable for software-defined transmission and are emerging as key drivers for flexible optical networks thanks to their scalability to higher order modulation. Specifically, the optical orthogonal frequency-division multiplexing (OFDM) and the discrete multitone (DMT), based on transmitting multiple orthogonal subcarriers/tones, provide a high spectral efficiency, as the subcarriers/tones are overlapped, and offer unique flexibility, adaptive bit-rate/bandwidth, and sub-wavelength granularity, compared to single carrier techniques, as each subcarrier/tone can support a different modulation format. On the other hand, new switching and aggregation technologies at sub-wavelength granularity are required to reduce the cost and energy per bit and to increase scalability, while maintaining a high throughput in terms of packets per second. These requirements can be met by adopting an optical based aggregation and switching technology based on Optical Packet Switching (OPS).

In recent years, new high-performance Internet applications, such as Cloud Computing and high-definition video streaming, are emerging. These applications have a common requirement for a high capacity network infrastructure, which can be provided by optical networks. However, each of these applications has its own specific access and network resource usage patterns as well as quality of service (QoS), Service Level Agreement (SLA) and dynamicity requirements. Therefore, dedicated and application-specific optical network services are desired to support each application category. As these categories evolve, the current technical and operational complexities, as well as CAPEX and OPEX considerations, will limit the ability of network operators to setup and configure dedicated optical networks, for each application type, in a scalable manner. Optical network virtualization is a key technology for addressing this issue. Network operators, by utilizing optical network virtualization, are able to partition and/or aggregate optical network resources into virtual resources, and then interconnect them together to compose multiple virtual optical networks (VONs). These multiple VONs can potentially coexist, using different network topologies and protocols, having their own specific QoS and SLA while sharing the same physical infrastructure.

Fixed-grid DWDM networks and electrical packet switching (e.g. MPLS) are not efficient for data rates beyond 100Gb/s

Network operators require dedicated application-specific optical networks, which can be governed by either GMPLS or OpenFlow control planes.

STRAUSS combines optical packet switching (OPS) for access and aggregation networks, and flexible WDM grid optical networks with software-defined BVT based on OFDM and DMT.

STRAUSS

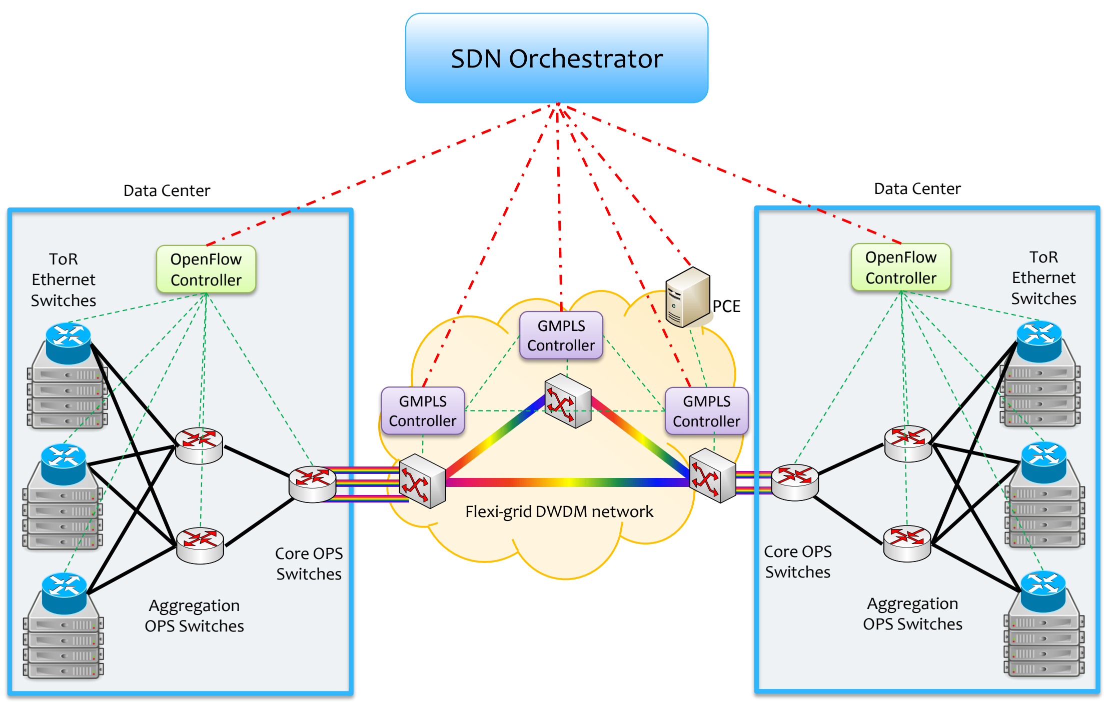
In an optical network supporting network virtualization, each VON requires a control plane for the provisioning of dynamic, adaptive and fault-tolerant network services. When a physical infrastructure comprises heterogeneous optical transport and control plane technologies, which do not naturally interoperate, an orchestration mechanism is required. It allows the composition of VON across different transport technologies (e.g. packet and circuit) as well as end-to-end network service provisioning across multiple VONs comprising different transport and control plane technologies (e.g. OpenFlow, GMPLS, or active stateful PCE).

Software defined networking or SDN is defined as a control framework that supports the programmability of network functions and protocols by decoupling the data plane and the control plane, which are currently integrated vertically in most network equipment. The SDN technology allows network operators to manipulate logical map of the network and create multiple co-existing network slices (virtual networks) independent of the underlying transport technology and network protocols. Furthermore, the separation of control plane and data plane makes the SDN a suitable candidate for end-to-end network service orchestration across multiple domains with heterogeneous and incompatible control plane and transport technologies. SDN can also provide a unified control plane platform for integration of packet and circuit switched networks for access, metro and core network segments.

STRAUSS considers SDN to create multiple co-existing virtual networks independent of the underlying transport technology and network protocols, and to provide an end-to-end Ethernet transport service across multiple domains with heterogeneous control planes (GMPLS and OpenFlow) and transport technologies (OPS and Flexible WDM grid).

STRAUSS use case: Intra and inter data center connectivity

Emerging cloud applications such as real-time data backup, remote desktop, server clustering, etc. require more traffic being delivered between data centers. To this end, it becomes necessary to deploy network architectures able to do so efficiently, in terms of cost, energy consumption and reliability. Ethernet remains the most widely used technology in the data center space, but the end-to-end provisioning of Ethernet services between remote data center nodes poses a challenging use case that would clearly highlight the benefits of the STRAUSS approach and innovations: a) within a single data center, optical packet switching (OPS) provides a fine-grained traffic granularity, and the application of a control based on software defined network (SDN) provides the required flexibility



and adaptive control in a very dynamic context with rapid changing forwarding entries and policies; b) the use of flexible WDM grid optical circuit switching (OCS) provides the long haul aggregated transport, enabling multi-carrier scenarios given the multi-domain support of a GMPLS/PCE control plane; c) the orchestration of both data plane technologies, coupled to the capabilities offered by a virtualized infrastructure would enable the operation of multiple data centers as one. Although SDN in the core would be possible, STRAUSS needs to account for existing deployments and return on investments, its benefits in such a relatively static environment with a lower number of routing policies are less evident and the multi-domain aspects are less mature compared to GMPLS.

In concrete terms, distributed data center domains are interconnected by means of a (potentially virtualized) optical core transport infrastructure. The data center domains are controlled by OpenFlow and the optical core transport infrastructure is controlled by GMPLS. While OpenFlow is specially adapted to single domain intra-data center networks (packet level control, lots of routing exceptions), a standardized GMPLS based architecture would enable dynamic optical resources allocation and restoration in multi-domain (e.g., multivendor) core networks interconnecting distributed data centers. In the data center domains, conventional Top of Rack (ToR) Ethernet switches are attached to OPS elements. Each node is used to efficiently aggregate the generated Ethernet data traffic into optical packets. The resulting optical packets form then the data flow that the bandwidth-variable transponders (BVT) equipped at the core OPS nodes will inject into the Flexible WDM grid DWDM network, to be transported towards the remote data center site. This backbone network offers the required huge transport capacity relying on all-optical flexible technology. The automatic control functions such as the provisioning within a domain, the equipment configuration, intra-domain path computation and domain traffic engineering (TE) decisions are performed by the control plane instances managing each network domain. To provide the above control functions from an end-to-end (inter-domain) perspective, it is necessary to have the interoperability and coordination provided by the SDN orchestrator.

Table summarizing the identified requirements of the data center use case and how the STRAUSS project addresses them.

	Data Plane	Control plane
Intra Data Center	Requirements: Thousands of layer 2 (e.g. Ethernet) traffic flows at different speeds (e.g., from Mbps to Tbps)	Requirements: Packet level control. Single domain. Multiple dynamic routing rules and low latency.
	STRAUSS approach: The OPS architecture proposed in STRAUSS aims to provide the granularity and dynamicity required by intra-data center networking, virtualizable for maximum flexibility.	STRAUSS approach: The SDN intra-data center control plane architecture proposed in STRAUSS is specially adapted to manage complex and dynamic routing policies in single domain scenarios.
Inter Data Center & Core Optical Network	Requirements: Tens of long haul, high capacity (beyond 100 Gbps) and low latency traffic flows	Requirements: Aggregated traffic control. Multi-domain control plane. Restoration. Static and pre-planned routing rules.
	STRAUSS approach: The Flexgrid architecture proposed in STRAUSS aims to provide low latency (e.g., optical) and long haul transmission beyond 100 Gbps per flow, virtualizable to allow operation of remote data centers as a single one.	STRAUSS approach: The GMPLS/PCE architecture for automated provisioning and recovery of high capacity optical flows in multi-domain (e.g. multivendor) core networks, backwards compatible with carriers that deploy GMPLS-based transport services that upgrade their network to flexible WDM grid.
Combined	STRAUSS approach: OPS/flexgrid architecture enabling transparent Ethernet services among distributed data centers, with flexible grooming based on OPS/OCS interfaces.	STRAUSS approach: SDN and GMPLS/PCE interworking enabling coordinated data center and core network resources orchestration.

Dissemination activities: ECOC 2013

The first results achieved within the STRAUSS project were presented at the 39th European Conference and Exhibition on Optical Communication (ECOC), which took place in London, 22nd-26th September 2013. ECOC is the largest optical communication and network event in Europe and provides the leading forum for new results and developments. In particular, two oral regular papers, one post-deadline paper, and one invited talk at the workshop "SDN Applications for optical network operating system: Challenges and opportunities" were presented in this edition.

One of the regular papers proposed a novel application-aware virtual data centre (VDC) provisioning method for distributed data centres (DCs) enabled by coordinated virtualization of optical OFDM network and DCs. Furthermore, it also proposed an adaptive VDC replanning method, supporting virtual topology shifting for accommodating DCs traffic variations. The second regular paper dealt with an Orchestrator architecture to dynamically configure and deploy virtual GMPLS-controlled MPLS-TP networks for data center interconnection over a shared WSON. The performance was evaluated in the ADRENALINE Testbed, in terms of the service setup delay. The post-deadline paper demonstrates, for the first time, an orchestration of elastic data center with inter data center transport network resources using a combination of OpenStack and OpenFlow. Programmatic control allows a data center operator to dynamically request optical lightpaths from a transport network operator for acceleration of inter-data center workflows. Finally, the invited talk presented the applicability of SDN principles for the control and management of optical networks within the STRAUSS EU-Japan project.

List of ECOC 2013 papers:

- Shuping Peng, Reza Nejabati, Mayur Channegowda, and Dimitra Simeonidou, "Application-aware and Adaptive Virtual Data Centre Infrastructure Provisioning over Elastic Optical OFDM Networks," in Proc. of 39th European Conference and Exhibition on Optical Communication (ECOC 2013), September 22-26 2013, London, U.K.
- R. Vilalta, R. Muñoz, R. Casellas, R. Martínez, "Data Center Interconnection Orchestration with Virtual GMPLS-controlled MPLS-TP Networks over a Shared Wavelength Switched Optical Network," in Proc. of 39th European Conference and Exhibition on Optical Communication (ECOC 2013), September 22-26 2013, London, U.K.
- R. Casellas, R. Muñoz, R. Vilalta, R. Martínez, "Applicability of SDN principles for the control and management of optical networks within the STRAUSS EU-Japan project," invited talk at the European Conference on Optical Communication (ECOC) workshop on SDN Applications for optical network operating system: Challenges and opportunities, September 22-26 2013, London, UK.
- T. Szyrkowiec, A. Autenrieth, P. Gunning, P. Wright, A. Lord, J-P. Elbers, A. Lumb, "First Field Demonstration of Cloud Datacenter Workflow Automation Employing Dynamic Optical Transport Network Resources Under OpenStack & OpenFlow Orchestration," (Post-deadline Paper) in Proc. of 39th European Conference and Exhibition on Optical Communication (ECOC 2013), September 22-26 2013, London, U.K.

The full list of publications within this first semester of the project are available at http://www.ict-strauss.eu/en/publications/year-2013.html