December 2013 — May 2014
Issue 2

STRAUSS newsletter

What's going on in STRAUSS?

STRAUSS has been very active in the second half year period of the project, corresponding to the third and fourth quarters. The third STRAUSS project meeting took place in Tokyo, Japan, on January 14-16, 2014. It was a very successful event to strengthen the collaboration between European and Japanese partners. The participants had the opportunity to discuss and define two joint experimental activities, targeting a post-deadline paper (PDP) for the Optical Fiber Conference (OFC 2014) and a regular paper for European Conference for Optical Communications (ECOC 2014), both of which have been accepted. The former joint work was carried out by Osaka University, Fujitsu, KDDI R&D Labs, University of Bristol, CTTC and Telefónica I+D, showing the first experimental demonstrator of 46-108Gb/s discrete-multi-tone (DMT) fixed-length variable capacity OPS over programmable, flexi-grid elastic optical path network, orchestrated via multiple OpenFlow controllers. The work for the ECOC 2014 paper presented the experimental assessment of ABNO-based network orchestration of end-to-end multi-layer (OPS/OCS) provisioning across SDN/OpenFlow and GMPLS/PCE control domains. This work was carried out by CTTC, University of Bristol, KDDI R&D Labs, Telefónica I+D and ADVA Optical Networking.

During this period, three live demonstrations were performed at OFC 2014, TERENA Networking (TNC 2014), and IP + Optical Network (IPOP 2014) conferences. At OFC 2104, Fujitsu showed a 400GbE transceiver by Optical DMT. ADVA Optical Networking demonstrated a SDN-Enabled colorless and directionless ROADM network at TNC 2014. Finally, an OpenFlow-based OPS/OCS unified control plane was presented at IPOP 2014 by KDDI R&D Labs.

In this issue

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Main Achievements in the first year of the project

After the first year of the project, all work packages are progressing according to the initial plans, and all the objectives for the first year have been successfully accomplished. The main achievements in this first year of the project are listed below:

- STRAUSS assessed the benefits of the DMT modulation over PAM modulation, and demonstrated the feasibility of 400Gbps transmission. An FPGA implementation of DMT transceiver was also demonstrated in a trial.
- BVTs based on the OFDM technology using low complex DSP and cost-effective optoelectronic front-ends have been investigated, experimentally demonstrating their sliceable functionality both in frequency and time domains. An FPGA-based real-time OFDM transmitter has been developed and experimentally tested.
- Distance-adaptive fixed-length variable-capacity (FL-VC) OPS has been demonstrated, and an intra-channel cross-talk tolerant FL-VC packet format has been proposed.
- A flexi-grid optical network prototype, using the architecture-on-demand (AoD) design approach for the optical nodes has been deployed in a laboratory.
- Three main use cases and a list of high-level requirements have been defined for the transport network virtualization, OpenFlow control and SDN orchestrator within multi-layer (OPS and flexi-grid OCS) networks.
- Preliminary architectures and interfaces for the proposed Virtualization Visor for multi-domain and single-domain virtual transport networks have been defined and implemented.
- Similarly, preliminary SDN controller architectures and protocol extensions have been defined and implemented for OpenFlow controlled OPS, OPS/OCS networks, and for GMPLS controlled networks with an active stateful PCE.
- Different SDN orchestrator architectures have been defined, implemented and experimentally evaluated, including the joint orchestration of IT and network resources for intra- and inter-datacenter connectivity.

STRAUSS participation in the Future Internet Assembly (FIA)

RESHAPING INFRASTRUCTURE FOR INNOVATION
FUTUREINTERNETASSEMBLY
ATHENS 18-20/03/2014

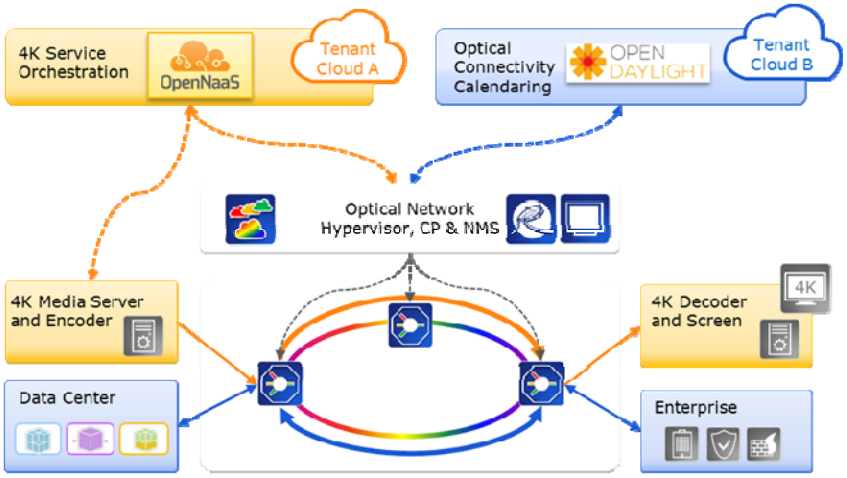
STRAUSS was present in the International Cooperation booth at the Future Internet Assembly (FIA), which took place in Athens, Greece, in March 2014. STRAUSS representatives were invited to participate in several FIA events. The first invited talk, “The impact of advanced optical technologies on Transport SDN” was given at the FIA session “Transport SDN”, jointly organized by STRAUSS and the ICT IDEALIST project. The second invited talk “Orchestration of heterogeneous optical networks for Ethernet transport” was given in the pre-FIA workshop “Network Virtualization”. Finally, in the context of the EU-Mexico workshop, STRAUSS summarized its main research activities with a talk entitled “Research activities on flexible optical infrastructure and SDN for network convergence, virtualization and inter-datacentre connectivity “.

STRAUSS

TERENA NETWORKING CONFERENCE 2014
19 - 22 May 2014, Dublin, Ireland

SDN-enabled colorless directionless ROADM network

At the Terena Networking Conference (TNC) 2014 ADVA Optical Networking demonstrated a 4K video service orchestration over an SDN-enabled colorless directionless ROADM network. In the demonstration, organized together with HEAnet, i2CAT and Eurotek, OpenNaaS was used as Orchestration Platform, OpenDaylight (ODL) as open source client SDN controller, and a multi-tenant capable Optical Network Controller / Network Hypervisor (ONH), which was partially developed in STRAUSS, to abstract and virtualize the optical infrastructure. The ONH is a multi-tenant capable application that creates and exposes abstract representations of the underlying transport network and exports that abstracted network to client SDN controllers. An abstracted network can be exposed as a single node or multiple nodes with abstract links. From the perspective of the exposed SDN interface the Network Hypervisor acts as one or more (virtual) nodes.



OpenNaaS, extended by a RESTful API to control the 4k video server, was operated by i2CAT. This setup enabled the orchestration of a network and available services. The ODL controller was managing another slice of the network and thereby demonstrating the multi-tenant features of the ONH at the same time.

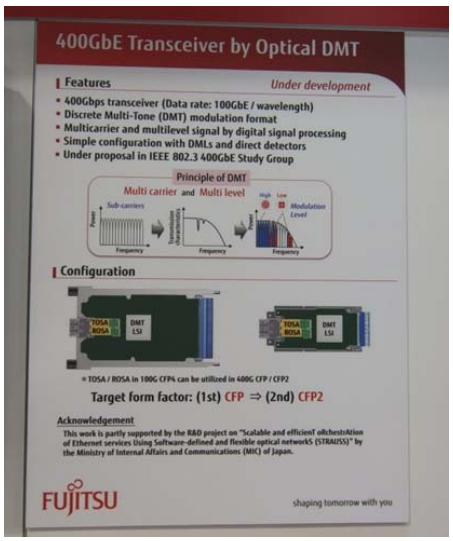
400GbE Transceiver by Optical DMT

The STRAUSS project demonstrated the technology for a 400GbE transceiver in the OFC2014 Exposition

The Optical Fiber Communication (OFC) Conference and Exposition is one of the largest exhibition shows of the optical networking and communications. 550 exhibitors exhibited the latest and future products and services on the market.

The STRAUSS project exhibited a 400 Gb/s Ethernet (400GbE) transceiver using the Discrete Multi-Tone (DMT) technology in the Fujitsu Optical Components (FOC) booth. The DMT technology is an orthogonal frequency multiplexing division (OFDM)-based multicarrier modulation format widely employed in xDSL systems. The high spectral efficiency of DMT technology enables the 100 Gb/s per wavelength transmission using a directly modulated laser (DML). The 400GbE transceiver relies on the wavelength division multiplexing of four 100 Gb/s DMT signals.

In the exposition, the 400 Gb/s transmission using a concept model of the 400GbE transceiver was demonstrated. Obtained experimental result were summarized, showing the main benefits of the technology. To the best of our knowledge, this STRAUSS demonstration was the world first exhibition of this cutting edge transceiver technology and attracted a large number of attendees.



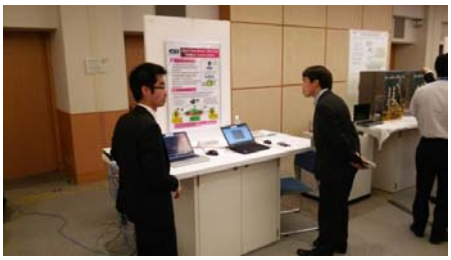
OpenFlow-based OPS/OCS Unified Control Plane

Recently, the volume of data transmitted within or outside data centers has dramatically increased with the spread of cloud business and the use of big data, and it is expected to be about 8 times more in 2020 than in 2012, justifying the deployment of 100Gbit/s-class optical network equipment and a unified control based on SDN as a means of reducing the operational cost.

At the 10th International Conference on IP + Optical Networks (iPOP2014), held between May 22 and 23, KDDI R&D Labs, along with other five companies/universities, successfully demonstrated the first 100Gb/s-class Software Defined Transport Network (SDTN) combining the wavelength division multiplexing equipment with optical packet switching (OPS) equipment controlled by an OpenFlow-based unified control plane, developed within STRAUSS.

Successful interoperability among 100Gbit-class core, metro and access optical networks with unified control plane

An open demonstration showed visitors a virtual optical network built between emulated data centers with 100Gbit/s optical network equipment. The metro core optical networks had been built as optical networks connecting data centers with 100Gbit/s wavelength division multiplexing equipment and 100Gbit/s-class optical packet and circuit integration switches. In the access part connecting to emulated data centers, a next-generation optical aggregation network had been deployed, and the optical network built with different types of equipment had been controlled by the SDN/OpenFlow-based unified control plane. The unified control plane had built a virtual optical network at the request (request for a bandwidth) from data center users.



This was the world's first open test of SDN/OpenFlow-based unified control of 100Gbit/s-class transport.

KDDI R&D Labs. and other five cooperating companies/university demonstrated, in collaboration with the iPOP2014 showcase, the first 100Gb/s-class Software Defined Transport Network (SDTN). The network combined the latest 100Gb/s-class WDM equipment with optical packet switching equipment controlled by OpenFlow-based unified control plane. This demonstration was partially supported by STRAUSS project.

What is a Sliceable Bandwidth Variable Transponder (S-BVT)?

In flexgrid optical networks, a data plane connection is established and switched based on variable-sized frequency slots and configured depending on the requirements of transport tributaries, such as data rate, modulation format, spectral efficiency and quality of service. To this extent, programmable bandwidth variable transponders (BVTs) provide different degrees of transmission robustness, adaptive spectral efficiency and spectrum occupation, based on varying a set of adjustable parameters according to the actual traffic demand. A software-defined BVT can be dynamically adapted or reconfigured to multiple rate, variable bandwidth occupancy or achievable reach by means of electronic digital signal processing (DSP).

Optical multicarrier modulations, such as orthogonal frequency division multiplexing (OFDM) or its simplified version, discrete multitone (DMT), are suitable technology candidates for software-defined transmission and are emerging as key enablers for flexgrid optical networks, thanks to their scalability to higher order modulation and distance adaptive capabilities. To further enhance the flexgrid network capabilities, the programmable BVT can be designed to be sliceable (S-BVT), thus able to generate multiple flows that can be routed into different optical paths and directed towards one or multiple destinations, depending on the traffic requirements. In order to achieve high flexibility and improved capacity, slice-ability can be implemented in both frequency and time. The S-BVT can be seen as a set of virtual transponders that generates an aggregated (in frequency or/and time) flow of high capacity, that can be sliced in frequency or time, assigning to each slice (i.e. flow with less capacity) a different subcarrier-frequency or time slot. A frequency-sliceable transceiver usually requires a set of sub-transmitters, and related optoelectronic front-end array, driven by multiple subcarriers, generated either by an array of laser sources or a single multi-wavelength source. For the time-sliceable approach, a single (fast)-tuneable optoelectronic front-end is needed in order to generate the corresponding time-slots for accommodating the different flows.

Within the STRAUSS project, different transponder technologies are investigated with the aim of maximizing the flexibility and scalability of the network and minimizing its cost and energy consumption. A preliminary version of a cost-effective hybrid time/frequency S-BVT, based on direct detected OFDM and low complexity DSP, has been experimentally assessed in the 4-node photonic mesh network of the CTTC ADRENALINE testbed. It has been demonstrated that the proposed S-BVT is capable of concurrently serving multiple destination nodes at variable bit rate in a realistic environment, switching between different wavelengths and time slots.

BVTs provide different degrees of transmission robust-ness and adaptive spectral efficiency , according to the actual traffic demand.

Sliceable BVTs are able to generate multiple flows that can be routed into different optical paths and directed towards one or multiple destinations, depending on the traffic requirements.

Within the STRAUSS project, a preliminary version of a cost-effective hybrid time/frequency S-BVT has been experimentally assessed.

OFC 2014 paper highligths

The Optical Fiber Communication Conference (OFC) is one of the largest international events for the latest advances in optical communications and networking. The achievements in the first 9 months of the STRAUSS project were presented in OFC2014, held in San Francisco, CA, USA, on March 9-13. In particular, 5 regular papers, 1 invited talk, and 1 post-deadline paper were presented.

The post-deadline paper session features the most recent high-impact results in optical communications research. The paper entitled "First international SDN-based Network Orchestration of Variable capacity OPS over Programmable Flexi-grid EON " was accepted as a paper in this highly competitive session. This research was conducted by five partners in EU and Japan.

In the paper, we experimentally demonstrated the network orchestration over a Fixed-Length Variable-Capacity (FL-VC) Optical Packet Switching (OPS) network testbed in Japan and an Elastic optical Path Network (EON) testbed in UK. The SDN-based Application-Based Network Operator (ABNO) in Spain orchestrates the OpenFlow controllers at each testbed and enables end-to-end transport service provisioning over the OPS-EON coexisting data plane. This could serve as a milestone architecture for elastic-bandwidth slice provisioning with the finest data granularity for SDN applications.

List of OFC 2014 papers:

- Y. Yoshida, A. Maruta, K. Kitayama, M. Nishihara, T. Tanaka, T. Takahara, J. C. Rasmussen, N. Yoshikane, T. Tsuritani, I. Morita, S. Yan, Y. Shu, M. Channegowda, Y. Yan, B.R. Rofoee, E. Hugues-Salas, G. Saridis, G. Zervas, R. Nejabati, D. Simeonidou, R. Vilalta, R. Muñoz, R. Casellas, R. Martínez, M. Svaluto, J. M. Fabrega, A. Aguado, V. López, J. Marhuenda, O. González de Dios, J. P. Fernández-Palacios, "First international SDN-based Network Orchestration of Variable capacity OPS over Programmable Flexi-grid EON," Th5A.2 **(post-deadline paper)**.
- R. Casellas, R. Muñoz, R. Martínez, R. Vilalta, L. Liu, T. Tsuritani, I. Morita, V. Lopez, O. Gonzalez de dios, J.-P. Fernández-Palacios, "SDN based Provisioning Orchestration of OpenFlow/GMPLS Flexi-grid Networks with a Stateful Hierarchical PCE," Th3I.2.
- T. Tanaka, M. Nishihara, T. Takahara, W. Yan, L. Li, Z. Tao, M. Matsuda, K. Takabayashi, J. Rasmussen, "Experimental Demonstration of 448-Gbps+ DMT Transmission over 30-km SMF Author block," M2I.5.
- R. Vilalta, R. Muñoz, R. Casellas, R. Martínez, S. Peng, M. Channegowda, T. Vlachogiannis, R. Nejabati, D. Simeonidou, X. Cao, T. Tsuritani, I. Morita, "Dynamic Multi-domain Virtual Optical Networks Deployment with Heterogeneous Control Domains," M3H.4.

Amazing success of STRAUSS project at OFC2014

The first STRAUSS testbed demonstration result has been accepted as an OFC post-deadline paper !

- J. Fabrega, M. Svaluto Moreolo, F. J. Vilchez, B. Rofoee, Y. Ou, N. Amaya, G. Zervas, D. Simeonidou, Y. Yoshida, K. Kitayama, "Experimental Demonstration of Elastic Optical Networking utilizing Time-Sliceable Bitrate Variable OFDM Transceiver Author block," Paper Tu2G.8.
- Dochhan, L. Nadal, H. Griesser, M. Eiselt, M. Svaluto Moreolo , and J.-P. Elbers, "Experimental Investigation of Discrete Multitone Transmission in the Presence of Optical Noise and Chromatic Dispersion," Paper Tu2G.7.
- Ramon Casellas, "A broader view of GMPLS/PCE and SDN", invited talk at OFC Workshop "Does SDN Spell the End for GMPLS?."

The full list of publications within this second semester of the project are available at http://www.ict-strauss.eu/en/publications/year-2014.html