GÉANT SDX - SDN based Open eXchange Point*

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***Abstract*—Different reasons make SDN an attractive choice for Service Providers like GÉANT: new functionality, improvement of flexibility and automation of operational processes. In this demonstration, we present the SDNization of *GÉANT Open* service, which is currently delivered through a set of Open eXchange Points (OXP) based on traditional (non-SDN) solutions. Using this service, GÉANT customers and approved commercial partners can interconnect via Layer 2 circuits. The SDN based service has been built on top of the Open Networking Operating System (ONOS) and runs on *white box switches* for the data plane. The live demo is based on remote access to the real prototype which runs in the GÉANT Cambridge Lab. During the demo we show how an operator can deploy the services and how the SDN network can be monitored and managed. Finally, we demonstrate how the infrastructure is able to automatically manage network events and adapt to network changes.**

***Keywords*—Software Defined Networking, Open Source, Software Defined Internet eXchange Point, Open Networking Operating System**

I. Introduction

Software Defined Networking (SDN) is a recent paradigm [2] potentially able to transform the design of both datacenter and wide area networks. SDN can be seen as a part of an even wider trend towards the softwarization of networks [3] [4], which implies a complete rethinking of how Service Provider networks are now structured. It is expected that this process will greatly increase the flexibility and efficiency of networks, reducing equipment and operational costs.

GÉANT [1], the 500Gbps pan-European network interconnecting 38 National Research and Educational Networks (NRENs), provides to the NRENs a wide range of connectivity services including point to point circuits at all layers, optical services, IP/MPLS, testbed service and so on [5]. In this demonstration, we present the SDNization of the *GÉANT Open* service. With the *GÉANT Open* service, the NRENs can connect with external (non-GÉANT) networks through the Open eXchange Points (OXPs). The OXPs are similar to the standard Internet eXchange Points (IXPs) [6], but with a fundamental difference. Inside an OXP, the customers (NRENs or external partners) request the establishment of Layer 2 circuits between end-points. The SDN version of the *GÉANT Open* service, namely GÉANT SDX, has been built on top of the ONOS controller [7].

ONOS provides a distributed Network Operating System (NOS) with a logically centralized network view. Scalability is provided partitioning the network resources. The control plane distribution offers also fault tolerance. In case of fault, a backup gains the mastership of the switches and notifies the others instances. The data plane itself is resilient: when a link

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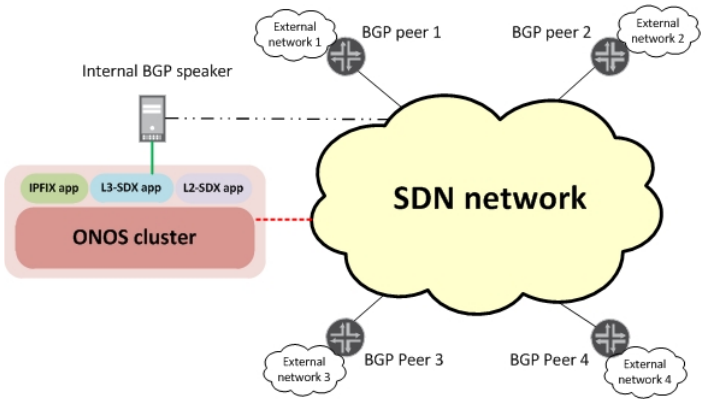

Fig. 1: GÉANT SDX architecture

or a network device fails, ONOS automatically provides traffic rerouting. On the NorthBound side, ONOS offers different abstractions to the applications. One of these are the Intents which provide applications with a network-centric programming abstraction allowing developers to program the network through the usage of high-level policies.

The GÉANT SDX is composed of two ONOS application called L3-SDX and L2-SDX. L3-SDX has been implemented on top of an existing ONOS application, called SDN-IP [8]. L2-SDX has been realized as a new ONOS application. L3-SDX and L2-SDX services. Both applications are available under a liberal open source license and can be downloaded from [9]. The Intent framework has been widely used for developing the two applications.

II. GÉANT SDX architecture

The so called *white box switches* have been used for the data plane. They are SDN enabled devices that could replace the traditional equipment and achieve relevant cost savings when compared to the legacy solutions. A cluster of ONOS controllers manages the SDN devices. The GÉANT SDX components, namely L3-SDX and L2-SDX, are designed as applications running on top of ONOS. The former provides IP connectivity and routing between participants through BGP protocol. The latter allows customers to create Layer 2 circuits between client interfaces. In practical terms, L2-SDX aims to substitute *GÉANT Open* service, while L3-SDX enhances the OXPs providing in addition the typical functionality of IXPs. Coexistence of the services in the data plane is realized through the use of slice mechanisms (e.g. VLAN tagging). Finally, the IPFIX application provides the monitoring functionality offering access to all the relevant statistics and exporting this information on the Northbound interface through the IPFIX protocol [10]. Figure 1 shows the high level architecture of the GÉANT SDX.

SDN-IP represents the starting point of L3-SDX. SDN-IP allows the interconnection of an SDN island with external networks leveraging on the BGP protocol. External participants can exchange routes and traffic through the SDN network. One or more internal BGP speakers peer with the external routers and act as a bridge between the external domains and the SDN-IP application. The SDN-IP application has two main tasks: i) to install flows for the establishment of BGP sessions; ii) to translate received routes into flows on the SDN switches (allowing the exchange of transit traffic). L3-SDX extends SDN-IP adding the support for new deployment scenarios, such as: i) the possibility to deploy multiple peers belonging to the same AS and interconnected through different connection points; ii) the support for the typical IXP scenario where all the BGP routers as well as the Route Server belong to the same subnet. An integration with IPFIX application allows to export, through IPFIX, the counters related to the BGP sessions and to the IP routes, enabling the realization of advanced monitoring tools.

As regards Layer 2 circuits, the L2-SDX application provides the necessary mechanisms for the service provisioning and monitoring. The human operators can manage and monitor the application through the CLI and GUI that accepts high-level requests from customers. L2-SDX provides operators with powerful APIs and abstractions. The customers can request the provisioning of Layer 2 circuits between endpoints. These requests are automatically translated by ONOS into SDN flows on the SDN devices. Moreover, it eases service management, e.g. enforcing isolation and avoiding several types of conflicts: i) operators see the abstraction of managing different virtual SDXs which contain a number of end-points modeled as edge connectors; ii) the resources (ports or VLAN tags) associated with a connector cannot be reused; iii) an edge connector can only be used in a single circuit and iv) a connector in a virtual SDX instance cannot be interconnected with a connector in another virtual SDX. The counter values relative to the virtual circuits are exported on the Northbound interface through an extension to the IPFIX application.

III. Demonstration

At present, the *GÉANT Open* provisioning process includes manual operations resulting in very long provisioning times. The objectives of the demonstration are to show the new functionality that have been added and how the introduction of SDN can improve the services lifecycle in terms of capability, flexibility and scalability. The GÉANT SDX demo runs in GÉANT Cambridge Lab and uses white box switches, hardware routers and virtual machines (VMs). Figure 2 shows the demo infrastructure. As regards the data plane, 4 Pica8 OpenFlow switches (P3922) constitute the OXP infrastructure, 4 Juniper MX series routers act as external peers and 4 VMs represent the sources/sinks of traffic. As for the control plane, 3 VMs compose the ONOS cluster and 1 VM runs the Quagga software acting as internal BGP speaker. In order to make a realistic experiment, some scientific routes (NREN specific prefixes) have been injected in Juniper routers and are actively exchanged between SDX participants. The demonstration will lead audience through the different operational phases of the SDX environment.

At the beginning of the demo, the new functionality of L3-SDX is shown. After the activation, L3-SDX automatically installs flows for the establishment of BGP connections between BGP speaker and two Juniper routers (MX1 and MX2). After a while, the BGP connections are established and the IP routes are exchanged. The operator shows BGP routes in ONOS controller, device status, installed OpenFlow rules and demonstrates the IP connectivity between SDX users. At this point, the operator shows the L2-SDX function activating a Layer 2 circuit between MX3 and MX4. Connectivity is demonstrated through the establishment of a BGP session and ping command. L2-SDX offers resource monitoring, which is shown to the audience. A new virtual circuit between MX2 and MX3 is created and the operator shows how this new addition influences the BGP protocol. In the next phase, the operator demonstrates the resilience and recovery features of the infrastructure: after crating a link failure, all affected intents are rerouted (order of 10 msecs), so that SDX users experience nearly no losses. Recovery features are demonstrated with the recovery of the link: the shortest path becomes available, L2-SDX and L3-SDX are able to re-route all the affected flows on this best path. Finally, the monitoring capabilities of the infrastructure are demonstrated. In particular a monitoring tool, built leveraging on IPFIX application functionality, is shown to the audience.

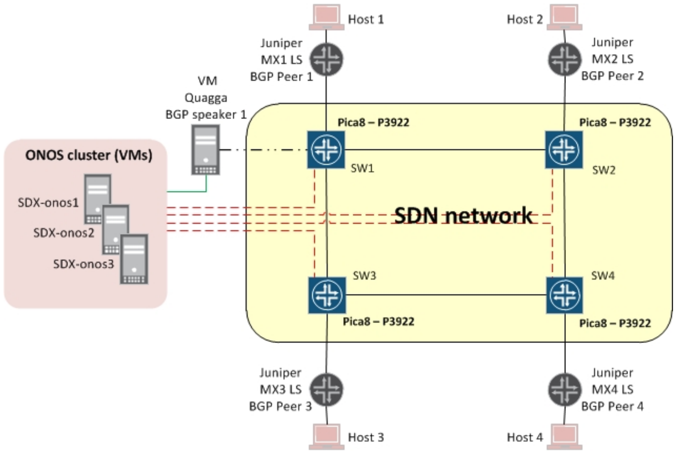

Fig. 2: DEMO setup

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