Moving an IP network to SDN: a global use case deployment experience at AmLight

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Abstract. *AmLight boasts a geographical SDN/OpenFlow network capable of slicing. Since the beginning, this provided the ability to implement testbeds in parallel with the production network. This paper describes a global experimentation network deployment running on a dedicated network slice at AmLight. The main goals of the testbed were a) end-to-end provisioning of Layer 3 connectivity without using legacy routers; b) transform Autonomous Systems (AS) running OpenFlow into IP/BGP transit networks; c) provide a feasible migration strategy from legacy IP/BGP networks towards an SDN/OpenFlow approach.*

1. Introduction

Since its SDN/OpenFlow adoption in mid-2014, AmLight has been running both a Software Defined production Network and different parallel network testbeds with no interference to each other [Ibarra et al. 2015]. In the mid-2015, AmLight joined GEÁNT [Geant 2016] and Internet2 [Internet2 2016] with the goal of creating a global, Layer 3 infrastructure connecting Research and Educational Networks (RENs), using Open Source software and SDN/OpenFlow devices. The project has been named *Global SDN deployment powered by ONOS*.

At AmLight, a dedicated network slice has been instantiated and on top of it the Open Source Open Networking Operating System (ONOS) [ONOS 2016a] and its SDN-IP [ONOS 2016b] application have been installed. The testbed initially connected RENs in Europe, Latin America, and the USA. Later in 2016, the Global SDN Deployment expanded to include other RENs, reaching more than thirteen institutions and controlling sixty OpenFlow devices, spanning five continents.

The testbed is composed of separate Administrative Domains, each one controlled by a dedicated SDN cluster, geographically distributed. The network brought is able to provide Layer 3 connectivity to its users with no need for legacy routers in the network core, as well as seamlessly interconnecting the SDN/OpenFlow domains with legacy IP/BGP transit networks.

The deployment phases have been entirely transparent to network users. Moreover, AmLight has identified potential benefits of adopting ONOS and its applications in its production network, including a reduced CapEx and a manageable and flexible system, which can provide all the service agility that REN communities need.

This paper is organized as follows: Section 2 presents the Open Source SDN Open Networking Operating System and its SDN-IP application. Section 3 introduces the Global ONOS SDN-IP deployment characteristics and the complexity involved. Following, Section 4 describes how the SDN-IP has been deployed at the AmLight network and some of the benefits observed. Section 5 provides the final considerations and the the next steps.

2. Describing ONOS and the SDN-IP application

Open Networking Operating System (ONOS) is a free, Open Source, carrier-grade SDN Operating System designed for Service Providers. ONOS has been architected based on three key principles: Scalability, High Availability, and performance. Moreover, it provides well-defined Northbound and Southbound abstractions and software modularity.

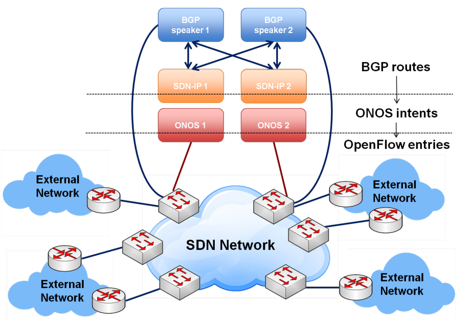

Figure 1. ONOS SDN/IP application architecture [ONOS 2016b]

SDN-IP is an ONOS application able to transform an Software-Defined network in an IP transit network, thus, a) connecting the SDN domain to legacy networks using BGP; b) allowing multiple Administrative Domains to communicate through the SDN network.

From ONOS perspective, SDN-IP is just an application that specifies their network control desires in a policy-based form, or *ONOS Application Intent Request*, and uses its services to install and update the appropriate forwarding state in the SDN data plane.

Figure 1 depicts the SDN-IP architecture: external networks using legacy IP/BGP peer with ONOS BGP speakers. The best route for each destination is selected by the SDN-IP application according to the iBGP rules, and finally translated into an ONOS Application Intent Request [ONOS 2016b]. Then, ONOS translates the Intents into OpenFlow entries and installs the entries into the SDN switches. Those rules are used to forward the IP traffic between the interconnected IP networks.

3. Global ONOS SDN-IP deployment

The Global ONOS SDN-IP deployment testbed has been first deployed in mid-2015 and expanded in 2016 connecting thirteen RENs and Research Institutions spanning five continents as depicted in Figure 2.

Besides AmLight, GEÁNT and Internet2, the current testbed facility interconnects ten additional Research and Education Networks (RENs) from different countries: Academic Network of Sao Paulo in Brazil (ANSP), Australian Academic Network (AARNet), Brazilian National Research and Education Network (RNP), Caribbean Knowledge and Learning Network (CKLN), Commonwealth Scientific and Industrial Research Organisation (CSIRO), Italian Research & Education Network (GARR), Korea Research Environment Open NETwork (KREONET), Latin American Cooperation of Advanced Networks (RedCLARA), Red Universitaria Nacional in Chile (REUNA), and the National Chiao Tung University (NCTU) from Taiwan.

The following motivations have been considered at the time AmLight decided to join the SDN Global Deployment: (1) create a global SDN network; (2) provide L2 and L3 connectivity without legacy equipment in the network core; (3) bring network innovation exploiting new applications developed internally at AmLight.

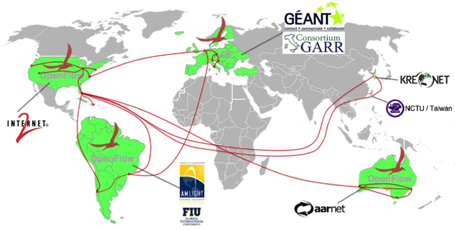

Figure 2. Global ONOS SDN/IP deployment map

Also, it is worth mentioning that as the network had the purpose to be a platform for innovation, both CSIRO/AARNet and GEÁNT have developed and employed their SDN/IP application to bridge the legacy IP/BGP and the SDN worlds. This accomplishment highlights how easy it is to dock a new software piece into ONOS and then make it interoperable with existing applications.

4. ONOS SDN-IP testbed at AmLight

Initially, to set up the ONOS SDN-IP application experiment at AmLight, engineers had to pay attention to specific OpenFlow features support in the switches, such as mac-address rewriting (OpenFlow 1.0 optional action *SET_DL_DST*), required by the SDN-IP application. After finishing the validation process on the environment, a dedicated network slice was created to provide isolation to this application.

The bigger square in the Figure 3 represents the architectural diagram of ONOS SDN-IP deployment at AmLight network, combining five OpenFlow switches, controlled by an ONOS cluster that is composed of two controller instances and running SDN-IP. Two special purpose routers, also knows as the BGP speakers, peer with the external routers provided by RENs and, at the same time, connect to the SDN-IP instances. They are considered special purpose routers due to this dual-capability.

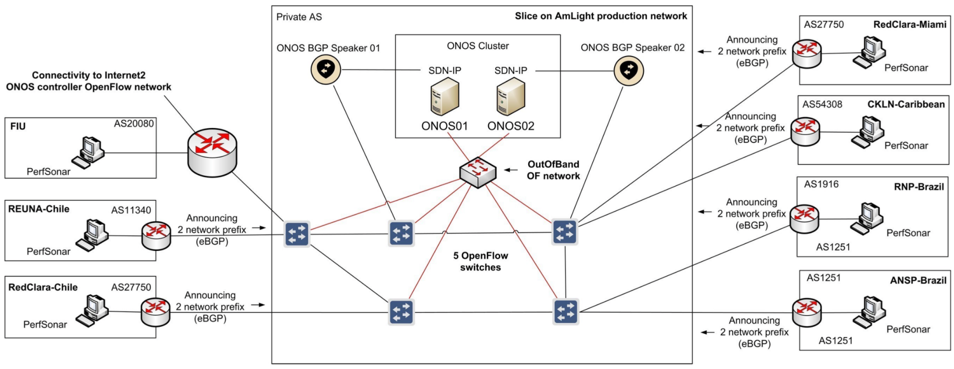

Figure 3. Architectural diagram of the ONOS SDN-IP deployment at AmLight network

Additionally, AmLight connected with International RENs, by bringing up a general purpose router, and legacy IP/BGP setup to have to peer with each of them. After receiving the routes, AmLight re-advertised them to the ONOS BGP Speakers, and by iBGP these routes were learned by all RENs, thus delivering end-to-end connectivity between all connectors.

Furthermore, all participants installed a perfSonar [ESNet et al. 2016] server on their sites and assigned to it an IP address from the pool of prefixes advertised in the testbed. By having these servers, it was possible to generate one-way delay measurements among the participants, and further, the results were presented to them through a web portal.

To summarize, the solution deployed was able to provision end-to-end Layer-3 connectivity without using legacy routers in the network core, transforming ASes running OpenFlow into IP (BGP) transit networks. Consequently, it can be recognized as an available migration strategy from legacy IP/BGP networks towards an SDN/OpenFlow approach.

5. Final Considerations

Joining the *Global SDN deployment powered by ONOS* provided excellent visibility and experience to AmLight's network. Its network virtualization capability has proved to be a valuable asset for testing new solutions using real network hardware and in a large scale.

The ONOS SDN-IP application deployment at AmLight validated that it is a nondisruptive solution that could be easily used as a migration path from legacy IP/BGP networks towards an SDN approach, in a reasonable period without requiring an immediate upgrade of networking devices.

As a future work, there are plans to attract more RENs and partners to join the testbed from Q2 2016. Also, with the imminent AmLight migration to OpenFlow 1.3, new ONOS features such as Multi-table pipeline support, QoS and IPv6 should be tested on a large scale using the testbed in place. Furthermore, the new ONOS Virtual Private Lan Service (VPLS) application is planned to be tested and validated in mid-2016 using a similar approach.

6. Acknowledgement

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