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SDN orchestration architectures and their integration with Cloud Computing applications

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ABSTRACT

Emerging cloud-based applications, running in geographically distributed data centers (DCs), generate new dynamic traffic patterns which claim for a more efficient management of the traffic flows. Geographically distributed DCs interconnection requires automatic and more dynamic provisioning and deletion of end-to-end (E2E) connectivity services, through heterogeneous network domains. Each network domain may use a different data transport technology but also a different control/management system. The fast development of Software Defined Networking (SDN) and the interworking with current control plane technologies such as Generalized Multi-protocol Label Switching (GMPLS), demand orchestration over the heterogeneous control instances to provide seamless E2E connectivity services to external applications (i.e. Cloud Computing applications).

In this work, we present different orchestration architectures based on the SDN principles which use the Path Computation Element (PCE) as a fundamental component. In particular, a single SDN controller orchestration approach is compared with an orchestration architecture based on the Application Based Network Operations (ABNO) defined within the International Engineering Task Force (IETF), in order to find the potential benefits and drawbacks of both architectures. Finally, the SDN IT and Network Orchestration (SINO) platform which integrates the management of Cloud Computing infrastructure with the network orchestration, it is used to validate both architectures by evaluating their performance providing two inter-DC connectivity services: E2E connectivity and Virtual Machine (VM) migration.

1. Introduction

Most emerging internet applications rely upon cloud-based services geographically distributed among different data centers (DCs). DCs are generating an increasing amount of dynamic, variable horizontal traffic [1] (i.e. databases synchronization or virtual instances migration), and vertical traffic between customers and DCs. The augment on the number of dynamic application-driven requests of network resources' reservation is moving network operators to find new network architectures which can provide automatic and efficient management of the setup and release of connectivity services. These new architectures must provide end-to-end (E2E) connectivity across different network domains. Intra-DC networks require a very dynamic, packet-based traffic control, while long-haul optical transport networks, which transport the inter-DC traffic, have carrier-grade, multi-domain control requirements.

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Network management and control systems are suffering an unprecedented evolution since Software Defined Networking (SDN) has emerged as the future networking paradigm. SDN proposes separating the control logic from the switching infrastructure by removing the 'intelligence' from the forwarding elements and concentrating it into a logically centralized SDN controller. OpenFlow (OF) [2] is a standard protocol developed within the Open Networking Foundation (ONF), which allows to externally define the forwarding behavior of the network infrastructure by characterizing the traffic as a combination of flow rules based on the packet headers. It has become the preferred SDN interface between control and data planes. SDN allows cutting costs from network infrastructure due to dedicated hardware that can be replaced by software-based switches installed on cheaper Commercial Off the Self (COTS) servers. This is one of the main reasons why SDN is attracting so much interest from a wide spectrum of the networking industry (especially on DC operators segment).

On the other hand, Generalized Multi-Protocol Label Switching (GMPLS) in combination with the Path Computation Element (PCE) is a mature technology with more than ten years of standardization progress, which offers a carrier-grade control solution for automatic circuit provisioning in Wavelength Switched Optical Networks (WSON). The Active Stateful PCE (AS-PCE) [3] has been demonstrated as a robust and effective management solution for the dynamic establishment and release of optical circuits or Label Switched Paths (LSPs) in GMPLS-controlled optical networks [4].

Operators which have already deployed GMPLS-based control solutions need to assure the return of investment of their current deployments, thus any network upgrade needs to account on existing control technologies. In this context, it arises the need of coordinating or orchestrating multiple, heterogeneous control planes. Inter-working between different control planes requires a higher, master entity (referred here as Network Orchestrator – NO) which automatically coordinates the processes to establish and release E2E connections through different network domains controlled by different control instances. A graphical description of this network scenario can be viewed in Fig. 1.

Recently, the ABNO architecture [5] has been designed within the IETF, based on standard protocols and components to efficiently provide a network orchestration solution for multi-layer and multi-domain networks. In this paper, we are presenting a full-defined ABNO implementation, with a modular, plugin-based, architecture to orchestrate multiple southbound controllers. Its northbound Application Programmable Interface (API) has been designed following the Representational State Transfer (REST)-ful principles to allow external IT applications [6] (i.e. Cloud Computing management systems) to directly request E2E connectivity services into the network. In addition, a previously presented orchestration approach [7] based on a single SDN controller is compared with the ABNO orchestration architecture.

The paper is structured as follows: in Section 2 an overall description of the orchestration process and different orchestration approaches is presented, also Cloud Computing and the need of integrating network resources into a jointly orchestration are examined and introduced. In Section 3, two different SDN orchestration architectures, ABNO architecture and Single SDN Controller Architecture (SC-Arch), are thoughtfully described and compared. To conclude the section, the SDN IT and Network Orchestration (SINO) application and its integration within the two previously described architectures is presented. And finally, Section 4 presents the experimental validation of both network orchestration architectures in the SDN/NFV Cloud Computing platform and Transport Network of the

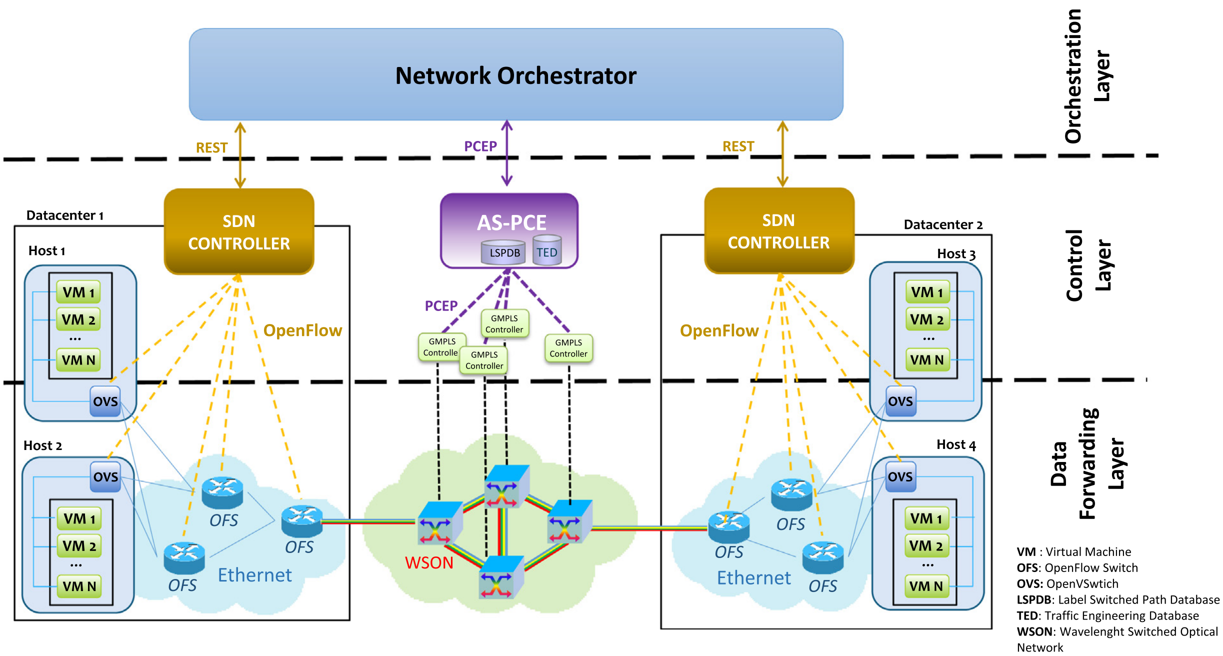

Fig. 1. Network orchestration architecture.

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