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Assessment of SDN technology for an easy-to-use VPN service

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HIGHLIGHTS

- We describe the architecture of an OpenFlow based multi-domain on-demand L3VPN.
- We give implementation details of the developed demonstrator.
- An easy to use web portal allows end-users to set-up and manage multi-domain VPN.
- Community Connect (CoCo) service can enable integrated resource management solutions.
- We performed functional and non-functional tests in a physical and virtual testbed.

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ABSTRACT

This paper describes how state-of-the-art SDN technology can be used to create and validate a user configurable, on-demand VPN service. In the Community Connection (CoCo) project an architecture for the VPN service was designed and a prototype was developed based on the OpenFlow protocol and the OpenDaylight controller. The CoCo prototype enables automatic setup and tear down of CoCo instances (VPNs) by end-users via an easy to use web portal, without needing the help of network administrators to do manual configuration of the network switches. Users from the research community, amongst others, expressed their interest in using such an easy-to-use VPN service for on-demand interconnection of their eScience resources (servers, VMs, laptops, storage, scientific instruments, etc.) that may only be reachable for their closed group. The developed CoCo prototype was validated in an SDN testbed and via Mininet simulation. Using the calibrated Mininet simulation the impact was analysed for larger scale deployments of the CoCo prototype.

1. Introduction

The advent of Software Defined Networking (SDN) is creating innovation opportunities for a wide range of use cases. A specifically promising application is the opportunity to create connectivity solutions in a more flexible way than with current Internet technology. To assess this opportunity and the maturity level of state of the art SDN technology, such as the OpenFlow protocol, the OpenDaylight controller and the Mininet simulation environment, an easy-to-use VPN service was developed and validated in the CoCo project. The CoCo project, that ran from October 2013 until March 2015, was one of the *open calls* projects funded by the European GN3plus project [1].

The demand for an easy-to-use VPN service has, for example, been identified in the eScience community. In eScience research the importance of networked services and facilities such as medical and genome databases, scientific instruments, visualization facilities, storage and cloud computing is increasing. However, current Internet services and facilities do not always provide the solutions that are required to meet the security and privacy requirements. It may require significant security configuration effort by network administrators as well as by users. Reducing the required configuration actions has been a long term endeavour for Internet researchers and significant steps have been taken. For example, in most intranet environments users already feel as if secure com-

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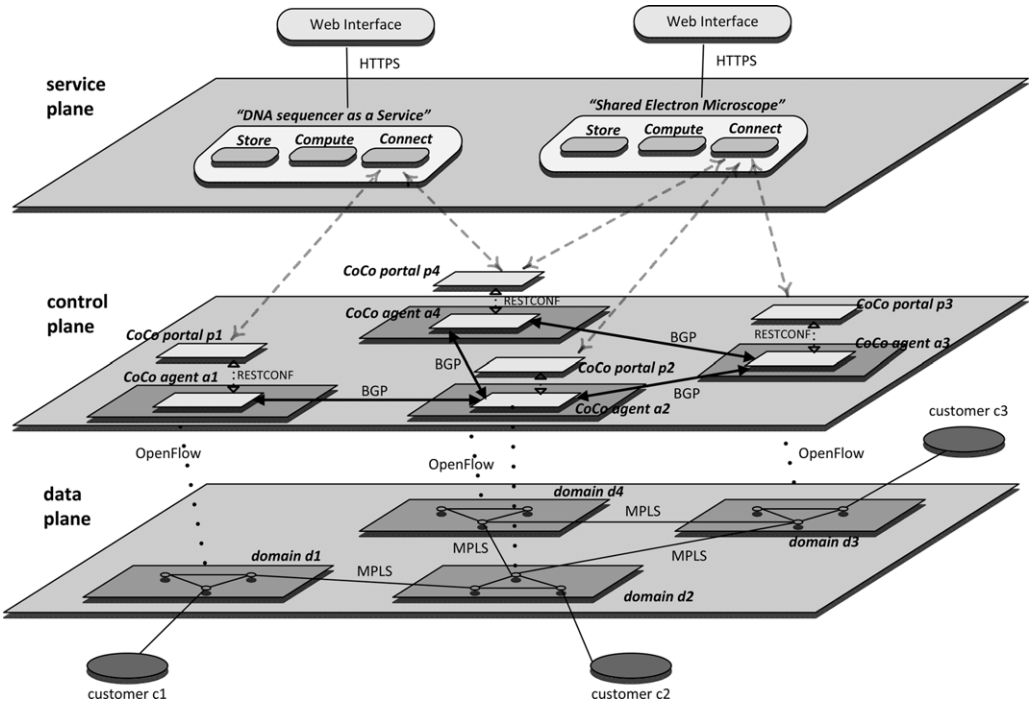

Fig. 1. CoCo Layered architecture.

munication comes out of the box and with HTTPS related technology secure client–server communication on the Internet has become child's play. A little more skilled user will be able to apply file encryption for securely sending its content to his peers. However, here is where current, user-friendly secure communication between end-users stops. More generic secure communication technology, such as Virtual Private Networks (VPNs) between multiple end-users, involves manual processes at one or more Network Operation Centers. This lack in secure communication technology leaves a variety of interesting applications out of scope. The need exists in particular in the eScience community as will be illustrated by the use case in Section 2.

The prototype developed in the CoCo project demonstrates how the OpenFlow protocol and the OpenDaylight controller can be used to create a new type of user configurable, on-demand, multi-domain and multipoint-to-multipoint VPN service. After a one-time initial general set-up of the CoCo service by the network administrator end-users will be able to set up and manage CoCo instances via an easy to use web portal, without having to rely on further manual intervention of the administrator. The programming interfaces of the CoCo prototype can also be exposed as API's to other applications, such that these other applications can automatically set up and tear down CoCo instances. The architecture for the CoCo service is presented in Section 3.

The CoCo prototype is developed on the SDN testbeds of SURFnet and the University of Amsterdam, that are equipped with OpenFlow switches and an OpenDaylight controller. During the development of the prototype several challenges in state of the art SDN technology were encountered, such as missing features that still need to be developed and bugs that need to be fixed. The solutions that were found for the CoCo prototype are described in Section 4.

In order to validate the CoCo prototype an automated test environment was developed for performing user-level experiments. In addition to the experimental validation in the SDN testbed a Mininet-based simulation environment was created. Mininet uses Open vSwitch as software OpenFlow switches, but in the test environment the same CoCo code was used and it also used OpenDaylight. The only difference was that software switches were used instead of hardware OpenFlow switches. With this setup Mininet simulations were run for validating the scalability of the CoCo prototype, beyond the boundaries of the number of OpenFlow switches and CoCo connected sites in the testbed. The results from these experiments and the scalability analysis are included in Section 5.

In Section 6 a discussion of the results is presented, including recommendations for following research. Finally, in Section 7 concluding remarks are presented about the ability of state of the art SDN technology to create connectivity solutions in a more flexible way than with current Internet technology.

2. Representative CoCo use case

A particular use case demonstrating the innovative power of the CoCo service is the *DNA sequencer as a Service* [2]. DNA sequencers are increasingly important instruments for scientists in the genomics science field. These sequencer instruments and the specific bioinformatics solutions required for the storage, processing and transport of their output are very expensive and get outdated relatively quickly, due to the current rapid developments. Therefore, research organizations can only justify such investments if the (re-)utilization of the sequencers and bioinformatics solutions is sufficiently high. The opportunity to strongly improve this return on investment by offering scientists from multiple institutes a DNA sequencing *as a* ,Service has been identified as a key innovation in the genomics research field.

Fig. 1 presents an overview of a technical solution for a DNA sequencer as a Service. The DNA sequencer as a Service is an example of a service plane extension of the CoCo service. The service plane is not part of CoCo, but can further facilitate the ease-of-use for the end user by incorporating the CoCo service in the control and data plane into an integrated service. Fig. 1 illustrates how authorized genomics experts can access a web interface of the DNA sequencer as a Service to set up the connectivity required for conducting an experiment.

Currently, the automation of DNA sequencing and processing is increasingly being applied via workflow management solutions.