Dynamic VLAN Provisioning in Software Defined Networking

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***Abstract*—In modern networking, logical segmentation of devices is crucial for enhancing security, improving network performance, and providing better visibility into device roles and purposes. Virtual Local Area Networks (VLANs) play a key role in achieving this segmentation; however, the manual provisioning and allocation of devices to VLANs can be tedious and error-prone. Software-Defined Networking (SDN) has emerged as a promising solution to address these challenges due to its centralized management, programmability, and automation capabilities. This paper proposes a method for dynamic VLAN provisioning using SDN, leveraging RESTCONF APIs for programmatic control and YANG data models for standardized configuration. The designed system allocates connected devices to appropriate VLANs or creates new VLANs based on predefined criteria such as connection type, physical location, or congestion levels.**

***Index Terms*—VLAN, Dynamic Provisioning, OpenDaylight, YANG, RESTCONF.**

I. Introduction

In networking it is important to be able to be able to logically split up the networking devices, as this can increase security by not allowing access to all network devices from a single connection [1]. It also helps give a better overview of the network devices and what purposes they serve. Furthermore, it can also increase network performance [2]. However, it can be tedious and complicated to provision VLANs and allocate devices to VLANs manually [1], [3]. The advantage of VLANs can be seen in Figure 1 which showcases how the different devices on the network are seperated based on which VLAN they are a part of, despite being connected to the same switch.

In more recent years, Software Defined Networking(SDN) has become a more popular and implemented approach to networking because of its advantages in some areas, like centralized management, automation and programmability [4], [5]. Because of the advantages of SDN, it is a good candidate to make the VLAN provisioning and allocation easier for network administrators with the aim of automating the process. To facilitate this goal, RESTCONF can be used to interact with the SDN API in order to programatically control the network [6]. Furthermore, for defining the models used to interact with the SDN, YANG Data models are used to make sure the schemes used are correct and interpretable by the SDN Controller.

The remainder of this paper is organized as follows. Section II summarizes related work. Section III describes the design, and Section IV describes the implementation. Finally, in Section V, The paper is concluded along with a discussion of future work.

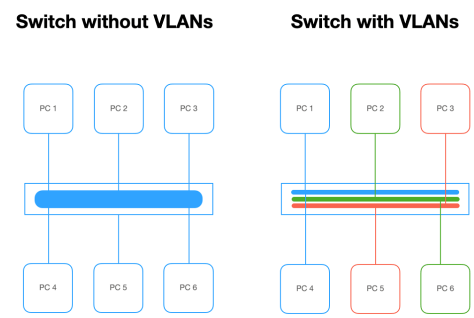

Fig. 1: Showcases the difference between networks with VLANs and without VLANs, different colors represent different VLAN. Source: NetBeez, https://netbeez.net/blog/introduction-to-network-switches-and-vlans/

II. Related Work

There have been other attempts at making VLAN management easier. Krothopalli et al. [7] focuses on VLAN management specifically for traditional enterprise networks. While Lu et al. [8] has looked at hybrid networks of SDN and traditional networks and the management of those.

III. Design

Figure 2 depicts how the flow of the designed program will be. The program will be querying the RESTCONF endpoint, `/rests/data/network-topology:network-topology`, of the OpenDaylight controller to check for any newly connected devices. This is due to the fact that RESTCONF does not support notifications, otherwise this would be better to avoid unnecessary repeated queries [9]. If there are any new devices, then the program has to decide which VLAN this device should be allocated to. If there are no suitable VLANs for the device, then a new VLAN for it is created and the device is allocated to that one. If a suitable VLAN is found, then the device can be allocated to the existing VLAN instead.

There can be several different ways to determine which VLAN is suitable for a device. It could be based on the

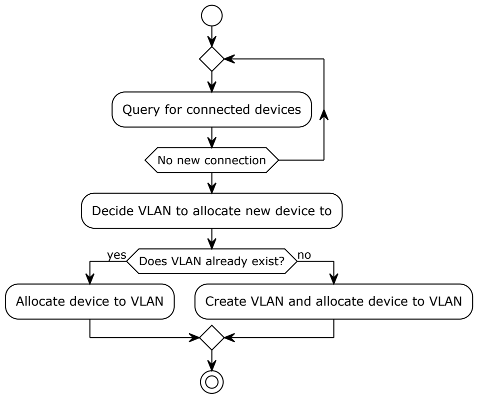

Fig. 2: Activity diagram showing the designed flow of the program.

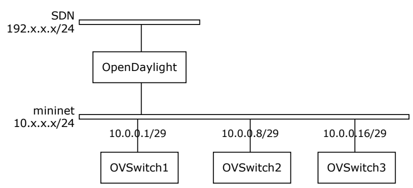

Fig. 3: Example of a VLAN configuration for 3 switches in Mininet

connection to the network, such that wired devices are on a separate VLAN to wireless devices. In bigger networks, VLANs could be separated by their physical locations. A third way of determining the suitable network could be to have a set size of VLANs and when there are no more spots on a VLAN a new one is created with the same size as the other VLANs. This could be done in order to limit the amount of network congestion on each VLAN.

In Figure 3 an example of a network with VLANs can be seen. The example network consists of 3 switches each with their own VLAN and set of addresses. In this way the different devices connected to each switch would be sepeated, but another way to provision the VLANs could be through a single switch and have multiple VLANs for one switch instead of a VLAN per switch. Figure 4 shows an example of 3 VLANs on 1 switch, which could be a more realistic example depending on the network.

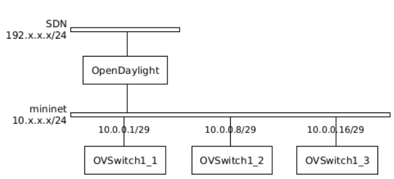

Fig. 4: Example of a VLAN configuration for 1 switch in Mininet

IV. Evaluation

A. Simulation Setup

OpenDaylight was used for the SDN controller and Mininet was used as the emulator for the network. Different network topologies were used to evaluate different scenarios.

B. Results

Unfortunately, we were unable to get the design implemented properly and thus have no real results to showcase. However, we still feel that the design is sound for implementation and could help with VLAN allocation and provisioning.

V. Conclusion

This paper looks at the challenges of dynamic VLAN provisioning. It introduces the design for a method of dynamically allocating devices to VLANs or provisioning new VLANs. This method can be used to automate and enhance VLAN provisioning based on different parameters, such as congestion, location or connection. Future work can look into more ways of allocating devices to appropriate VLANs and implementing QoS and access lists into the VLANs as well.

Acknowledgments

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