FACULDADE DE ENGENHARIA DA UNIVERSIDADE DO PORTO

API design and implementation for management and configuration of SDN products

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Resumo

Abstract

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Abreviaturas e Símbolos

SDN	Software Defined Networks

Introduction

1.1 Context

Public and private access to the internet is a basic necessity in the modern society. In a modern setting, the rising requirements that exist in supporting users with mobile devices and their own computers must be met, in order to provide a stable and secure platform to ensure connectivity across different locations, devices, and more. In this context, managed Wi-Fi networks are defined as a way to deploy networks that are optimized in order to meet the specific requirements of users/ applications.

As we see the proliferation of these systems, due to increasingly demanding environments, the market for managed Wi-Fi systems is planned to reach \$1.7 billion in 2018. This raise in market is related to the distribution of the enterprises, where they are composed of several smaller locations, often lacking specialized IT staff that have strong networking capabilities, or even just the infrastructure is not suitable to installing these complex systems.

The creation of the As-A-Service model comes in consequence of these previous factors. In this specific case, the development of managed Wi-Fi as a system following the Infrastructure-As-A-Service (IAAS) mentality has allowed for the removal of investment in large WLAN infrastructure, related not only to the maintenance, but also the planning, operation, and installation of the service, allowing to transfer the cost to a trusted third-party.

The previous paragraph shows a brief introduction to the motivation that lead to several companies to try to develop and support these sort of services. One of them, and the main proponent of the theme of the dissertation is Berlin Institute for Software Defined Networks - BISDN, and this research integrates a trial system that is being implemented, and we aim to solve one of the problems they faced during the road to productisation.

This document serves as an introduction to the future work to be developed in the dissertation. The organization is this report is as follows: in chapter 2, the state-of-the-art of similar mechanisms and a bibliographic revision is done; in chapter 3, the specific details of the problem are presented, and we start detailing some aspects that should be featured during the development of this dissertation; then we try to define a possible work plan, by defining a timeline, and approach to the development of the final product.

1.2 Motivation

By analyzing the current market offerings of large scale Wi-Fi solutions, we can see that the most offerings have a non ideal solution to cover the need of constant access to the internet, either by supplying a system that is not well optimized to cover the entire use cases, or by providing a system that isn't scalable, of fixed configuration, and that needs large, specialized IT teams that aren't always available due to several constraints.

The issue of user information, in the scope of these networks, is a sensitive one. The storage and manipulation of this data should be used in the most secure way, to safeguard their privacy, and there should be safeguards in order not to lose the entire data.

In this case, the theme of the future dissertation is proposed, to develop a tool that, in integration with larger systems, can provide a way to solve this problem.

1.3 Goals

During the development of this dissertation, we aim in exploring the possibility of using cloud technologies to store, in a secure and redundant way, customer configuration and session data, to be used while deployed into large scale managed Wi-Fi systems already in testing. Our main goal, should feature an analysis of available cloud database solutions, and choose the better platform to suit our needs. It should also feature an in depth analysis of session information in a Wi-Fi managed network. By combining the two, we aim to propose a solution for a problem in deploying public Wireless LAN, the management of several users.

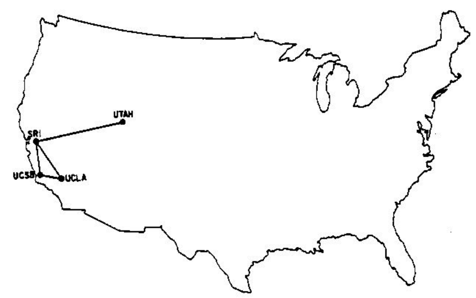
Berlin Institute for Software Defined networks

Literature Review

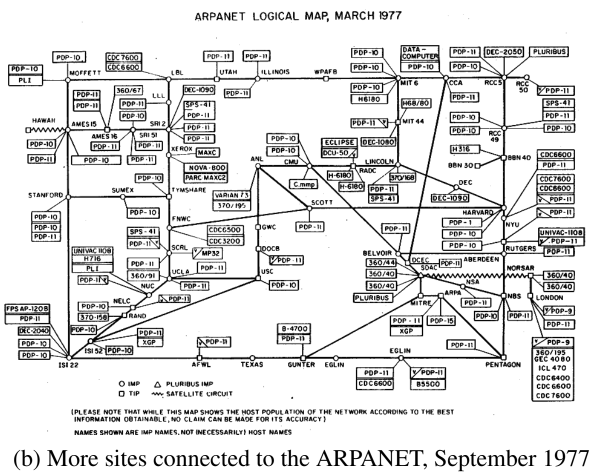
3.1 Computer Networking

3.1.1 Historical context

A computer network is a way to transfer digital information from point A to point B, via an established link between the two. In the early days, the demand to create an interconnected network of data sharing appeared from academic research and military needs, and since the introduction of these innovations, many American universities started to join in the this network, called ARPANET.



(a) Early ARPANET schematics, appr. 1969



(b) More sites connected to the ARPANET, September 1977

Figure 3.1: ARPANET evolution

As the advantages of having an interconnected network of computers became clearer, and with the surge of some others, such as CYCLADES, the french investigation research network, the need to connect the existing networks was rising, and that was one of the first steps of creating a global network, later known as the Internet. Some of the essential mechanisms that can still be found to this day were also developed in the ARPANET, like FTP and e-mail.

One of them was introduced in 1981, RFC 793 [**?**], and with it TCP was "invented". The main motivation for this development was the introduction of an end-to-end, connection oriented, and reliable protocol that allowed for the standardization of several different protocols. Also in this document, the definition of a OSI model, like the one that is prevalent today, or the definitions of reliability, are present, and continue to be relevant until today.

Figure 3.2: The current OSI model

One

3.1.2 Market data

By continuing to evolve and increase in both functionalities and users, the Internet as we know it is a global network, encompassing several protocols, and allows for instant communication of people around the world. A report indicating this evolution allows for some interesting conclusions about the state of the Internet market until 2021. This forecast was developed based on data originating from projections made from some Telecom and Media groups, direct data collection, and some estimates.

Global IP traffic As the report mentions, the monthly traffic, per capita, in 2016 is around 13 GB, and in 2021 is projected to be at 35 GB

Mobile devices traffic While today wired devices still make up for the majority of IP traffic, in 2021, traffic originating from Wi-Fi and mobile devices should account for 63 percent of the total traffic

Smartphone/ PC traffic By comparing the predicted evolution of smartphone/ pc traffic, the trends indicate that smartphone traffic should exceed fixed PC traffic.

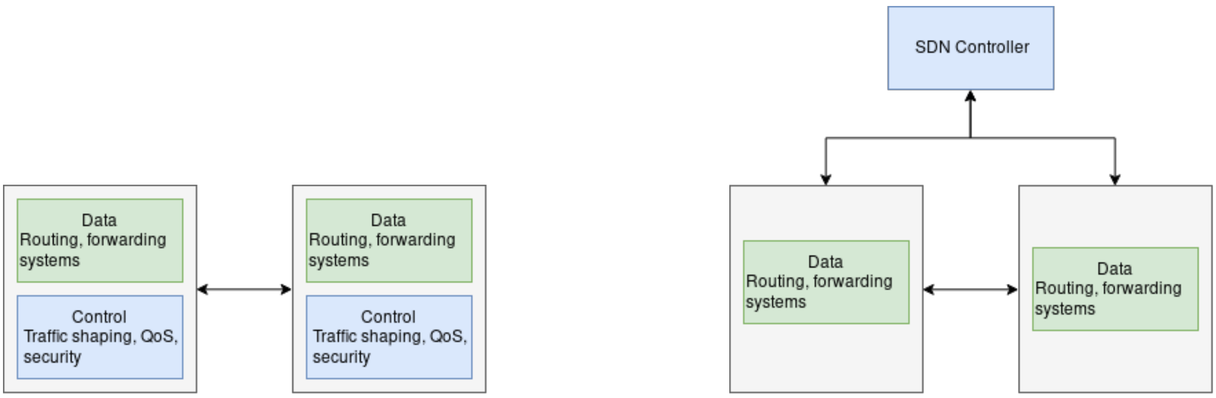
The previous points while obvious estimations, show a clear evolution in the way that Internet is usually accessed, and that is the

3.2 Software Defined Networking

As described in the previous section, there is a clear evolution of requirements, and this evolution was possible due to the adaptation of the exiting technologies to support better, and more efficient protocols that could carry the large amount of data that is transmitted every second. With that in mind, and in order to reduce costs to the service providers, simplify deployment and maintenance operations, developments in Software-Defined Networking (SDN) and Network Function Virtualization have been growing since 2010.

This new paradigm introduces programmability in the configuration and management of networks, by consolidating the control of network devices to a single central controller, achieving separation of the control and the data plane, and supporting a more dynamic and flexible infrastructure. Another important paradigm, that follows the development of SDN, is the concept of Network Function Virtualization. This concept allows to remove the amount of *middleboxes*[1], by replacing these with generic software applications.

The essence of SDN/NFV is described in a short manner if the Open Networking Foundation (ONF) paper: *In the SDN architecture, the control and data planes are decoupled, network intelligence and state are logically centralized, and the underlying network infrastructure is abstracted from the applications*. The following picture defines both of the approaches to network, the traditional one, where the data and control plane are just one, and the SDN way, that considers that application and control traffic should be considered in two different ways.



(a) Traditional networking architecture (b) SDN architecture

Figure 3.3: Traditional vs SDN network architecture

[1]Computer networking device that does some operations on traffic, excepting packet forwarding. Examples include caches, IDS's, NAT's, ..

One example of the operation of a switch in the SDN model is the following:

- A switch runs an agent, and this agent is connected to a controller;
- This controller runs software that can operate the network, managing flow control rules, and collecting information, enabling a full view of the network from a central node
- While this controller can be logically centralized, for fault-tolerance and high availability purposes it can be distributed, and by optimizing datamodels and providing caches, one of the earliest ONOS prototypes was able to achieve a distributed Network OS that could be applied to production networks [2]

More details on the technology that runs this model can be found in the next chapter.

After analysing some examples of deployment of the SDN model, the analysed literature provides some insights on the requirements that platforms using this paradigm need to obey [4].

- **High Performance** Regarding performance as a metric indicated
- **High Availability**
- **Fault Tolerance**
- **Monitoring**
- **Programmability**
- **Security**

3.2.1 Why?

3.2.2 Challenges

3.2.3 Observed implementations in the industry

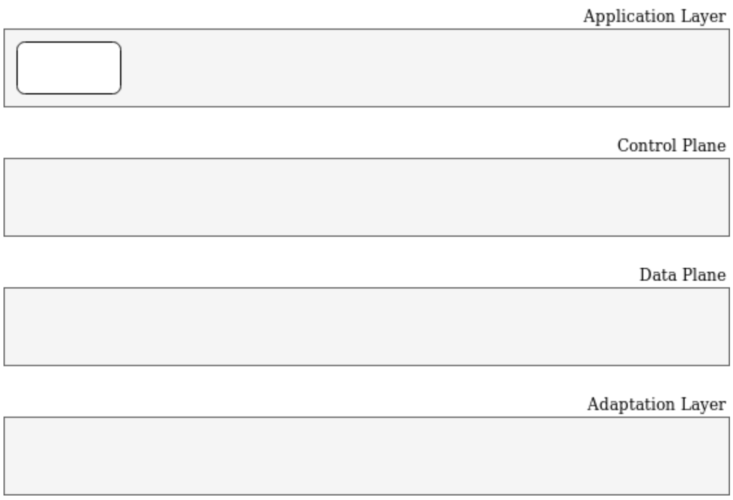
3.3 Cloud Computing

3.4 Databases

Technology Overview

After a brief introduction, encompassing the history, and some of the requirements in the technologies that support the developed work, this chapter focuses on giving a detailed description of the infrastructure supporting the developed work. This chapter is organized in the following matter: in the first section, we focus on SDN/NFV platforms, and the OpenFlow platform; in the second section, an introduction to cloud computing is the main topic, while also clarifying some of concepts of containerization and virtualization, and how these techniques support the SDN model; in section three, some methods of describing links are explained; in section four, there is an analysis of how to monitor and control the SDN platform; and finally in section five we describe how some databases can serve as a backend, and also presenting some interesting new alternatives to the most common ones.

4.1 SDN / NFV



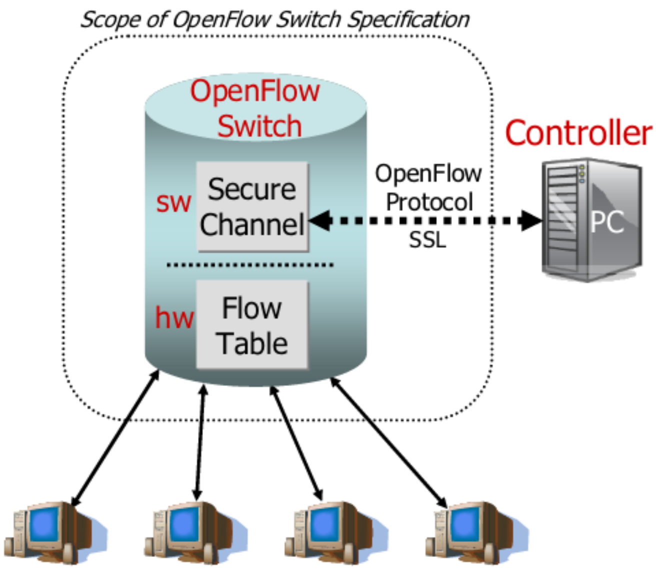
Given that this chapter focuses on a more technical view of the technologies supporting the various components of the developed system, the previous image is defining the logical separation between layers, the relationship between these layers, and the protocols used for connection. In a general case, we can define two essential regions, Northbound and Southbound, because this separation provides us with two main interfaces: **Southbound**, providing interfaces between controller and data plane; and **Northbound**, providing connection between the network infrastructure, and applications and services.

By following the logical separation as provided in the previous figure, we can define the requirements needed for each of the interfaces.

4.1.1 Southbound

4.1.1.1 OpenFlow

One of the most important components of current SDN technologies, and one of the key components that allowed for the proliferation of SDN platforms, OpenFlow is a protocol that was released in order to improve experimentation in networks, due to a lack of inovation in this field. The way this problem was approached was to develop a protocol that allowed for the creation of programmable networks, and also to deal with a way to decrease dependency on closed hardware platforms.



4.2 Cloud computing and SaaS

4.2.1 Containerization vs Virtualization

4.3 Link discovery and control

4.4 Infrastructure Management/ Configuration

4.4.1 Data Models

4.4.2 Management Protocols

4.4.2.1 SNMP

4.4.2.2 NETCONF

4.4.2.3 gRPC

4.5 Databases and SDN

API Design

Designed System

References

[1] M. Schwartz and N. Abramson. The Alohanet-surfing for wireless data [History of Communications]. *IEEE Communications Magazine*, 47(12), 2009.

[2] Pankaj Berde, William Snow, Guru Parulkar, Matteo Gerola, Jonathan Hart, Yuta Higuchi, Masayoshi Kobayashi, Toshio Koide, Bob Lantz, Brian O'Connor, and Pavlin Radoslavov. ONOS: towards an open, distributed SDN OS. pages 1–6. ACM Press, 2014.

[3] Ian F. Akyildiz, Ahyoung Lee, Pu Wang, Min Luo, and Wu Chou. A roadmap for traffic engineering in SDN-OpenFlow networks. *Computer Networks*, 71:1–30, October 2014.

[4] Hitoshi Masutani, Yoshihiro Nakajima, Takeshi Kinoshita, Tomoya Hibi, Hirokazu Takahashi, Kazuaki Obana, Katsuhiro Shimano, and Masaki Fukui. Requirements and design of flexible NFV network infrastructure node leveraging SDN/OpenFlow. In *Optical Network Design and Modeling, 2014 International Conference on*, pages 258–263. IEEE, 2014.

[5] Hiroaki Hata. A study of requirements for SDN switch platform. In *Intelligent Signal Processing and Communications Systems (ISPACS), 2013 International Symposium on*, pages 79–84. IEEE, 2013.

[6] Sakir Sezer, Sandra Scott-Hayward, Pushpinder Kaur Chouhan, Barbara Fraser, David Lake, Jim Finnegan, Niel Viljoen, Marc Miller, and Navneet Rao. Are we ready for SDN? Implementation challenges for software-defined networks. *IEEE Communications Magazine*, 51(7):36–43, 2013.