SDN and Openflow

for beginners

with hands on labs

Vivek Tiwari

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About The Author

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Vivek Tiwari holds a Bachelor's degree in Physics, MBA and certifications from multiple vendors including Cisco's CCIE. With double CCIE on R&S and SP track under his belt he mentors and coaches other engineers. Vivek has been working in Inter-networking industry for more than twenty years, consulting for many Fortune 100 organizations. These include service providers, as well as multinational conglomerates. His six plus years of service with Cisco's Advanced Services has gained him, the respect, and admiration of colleagues and customers alike. His experience includes and not limited to network architecture, training, operations, management and customer relations; which made him a sought after coach and mentor, as well as a recognized leader.

Vivek is also the author of

Your CCIE Lab Success Strategy the non-technical guidebook.

Stratégie pour réussir votre Laboratoire de CCIE: Le guide non-technique.

Your CCNA Exam Success Strategy the non-technical guidebook.

Your CCNA Success Strategy Learning by Immersing.

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Kai Wang

Sean Garrett

Harish Dommathamari

Dean Bahizad

Lastly, I would like to thank everyone else who assisted and encouraged me with this work.

Reviews

Kai Wang CCIE # 6130

This book was an easy read and will be very accessible to novice SDN and OpenFlow learners. A great introduction for anyone that would like to learn about this new technology!

Sean Garrett CCIE # 11390

This book reads well and does a great job in breaking down SDN fundamentals into easily understand analogies. If the reader is contemplating using SDN at the enterprise or service provider level, this is an excellent resource to read. It was good to see the concepts expanded into a broader scale, spreading across disparate networks and protocols. To the casual reader and someone not very familiar with SDN, this book will help to explain the technically challenging aspects, and gain a better understanding SDN fundamentals in the network.

Harish Dommathamari CCIE # 9891

SDN is one of the most talked about industry terms today and this book is the definitive read on getting to understand SDN and OpenFlow. Well-structured and simple to read, combined with hands on labs on SDN using OpenFlow this book serves as a good beginner's guide for anyone who is interested to learn about SDN.

Dean Bahizad CCIE # 18887

Before reading this book, I really had no idea where to start with Software Defined Networking (SDN), just a vague definition. The easy to follow format and concrete examples really helped me understand SDN more. (The Borg example is really good and easy to relate to).

I also found the step-by-step instructions on how to set up the hands-on lab really helpful. Great book for anyone new to SDN—worth every penny!

Dedication

I would like to dedicate this book to all those **network engineers** who took their time to answer my questions, even the ridiculous ones. Their deep understanding of networking, patience and the willingness to impart knowledge has helped me to be what I am today.

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Chapter 1 - Why this book?

I had been hearing about SDN for quite some time. This was supposed to be a technology disruption that was much needed for the networking market. Then came July 23, 2012: A company called Nicira was acquired by VMware for $1.25 billion. They spent such a hefty amount on a startup because Nicira does the same for network virtualization as VMware did for server virtualization.

This $1.25 billion weight behind the technology made SDN mainstream. The buzz going around the technology world was that Nicira is going to threaten giant companies like Cisco and Juniper. SDN created a lot of debate and discussion throughout the networking world. It came out of the geek's realm and became a buzzword. The Nicira spotlight brought SDN into focus for the technology savvy CEO's and CTO's. In short, all this commotion put SDN on the tech horizon of a whole lot of companies.

As I was finishing my other book, news articles and write-ups were clogging my inbox and I was being asked about SDN by friends and customers alike. I looked around and there was a plethora of information; but, like many other things on the internet, there was a big pile of *jumbled* information. There was a lot of information that was already out of date and then there were articles which were biased towards or against SDN. On one end of the spectrum, there was too much information by people who didn't know much about SDN, which sometimes translated into misinformation. On the other end of the spectrum, there was too much technical information, which became OHT (overhead transmission) and put you to sleep.

I looked at YouTube and there were hundreds of videos explaining SDN from individuals explaining their view of SDN to live product demonstrations from different players in this game.

Note: Interestingly a Swedish company www.tail-f.com did a survey and found out that 87% of NA enterprises see SDN as more important than cloud or virtualization, yet only 51% know what SDN is! **The key here is not the percentage numbers but the fact that SDN needs much more awareness.**

I jumped on to Amazon, and lo and behold, there was just one book on SDN. I was surprised, but, at last, I thought there was something I could find that would have relevant information in an ordered fashion. A 400-page book of technical reading was not exactly what I was looking for; but even that was a pre-order and was not going to be available for another 90 days or so.

That is when I decided to write this beginners guide. I wanted to keep this short and to the point: something that you can read in three or four sittings. A book that gives you an idea about SDN, helps you speak intelligently about it, enables you to ask intelligent questions, and even gives you the sense if this is something that you would want to pursue further.

If you are hands-on engineer like me then you learn more by getting your hands dirty in the sandbox (your lab). That is the reason I have added the hands on portion to this book also. This will get you on your journey to the next realm of networking.

I also wanted to stick to the basics and be vendor neutral. Since I am basing this book mostly on version 1.0.0 of OpenFlow (version 1.3.3 is the latest) this book should stay relevant for anyone who wants to test the waters. Most of the vendor products now support OpenFlow version 1.0.0 and support for higher versions is being added.

Some of you may find this book very basic while others may also find this insightful. It all depends how much you have read and heard about SDN and from whom. Whatever you feel about the book, I am happy to hear from you. Your comments and suggestions to this book will be valued immensely. I do not claim to be an expert on SDN and OpenFlow. There are many others who know more than I do and I will be mentioning the blogs and websites that I have seen of great value to learn about SDN at the end of this book in the resources section.

This book will give you the concise knowledge that you need to start on SDN in a step by step fashion which will save you hours and hours of searching and sorting of online articles and blogs which may have become too old to be relevant, be colored by views of people who are for or against SDN or views that may be there to promote one company product or the other. My knowledge of SDN came from reading hundreds of blogs and informative articles. As a result, this book is the condensation of this online knowledgebase and my personal knowledge and experience.

Part I: What is SDN?

Chapter 2 - What is SDN?

That is the first relevant question to ask. What is SDN?

You will hear a lot of statements like:

- SDN decouples the control plane from the data plane.
- It allows us to change network behavior dynamically.
- SDN (Software defined networking) is exactly what it says, network behavior defined by software.
- It opens the door to network intelligence so that you can get lot more value from your network.

Like everything else in networking, the answer is, "*IT DEPENDS*."

For a **Network Engineer**, it is the next cool technology which you will need to keep a close watch on. If this technology meets or exceeds the expectations, then this is the next big evolution of networking and you will need to be prepared to ride the wave.

For a **Technical Sales Engineer** , it is not only the buzz word that you can use every now and then, but also something that you have to be aware of and ready to answer questions to customer network Architects and CTO's. They will need to address questions like, how is this technology relevant to the customer and how is their current hardware compatible with this technology? What are the added benefits to them?

For a **Network Manager**, it is something still on the horizon and may affect you three to five years from now. Those at the select few organizations that like to be on the cutting edge will think different for sure as they may have SDN in the labs or even a pilot somewhere. However, like any other new technology, there will be the initial technology absorption pains. In the end, this will make the job easier as configuration management and traffic flow within the network will be controlled in a more granular and centralized fashion. This means more control for the network manager.

For a **CTO** it means that the overall hardware costs will decrease while they can roll out better services for their organizations. These services will be flexible and scalable which will be easier to operate.

For a P**rogrammer** it means creating API's that allow software to dynamically control network devices at a depth down to the ASIC level on the ports of a switch.

For **Software Developers** this open field will grow as much as their imagination can. All the current applications can take advantage of this new flexibility of the applications talking to the network infrastructure and the network responding dynamically to its needs.

So what the *&^%$ is SDN?

One word that came to my mind by reading about SDN was "BORG". For those of you who have not seen *Star Trek*, the Borg's are an alien race that can assimilate you and then control you from a central hive mind. I am sure some Star Trek fans can dig deeper into this and start picking apart the difference between SDN and BORG's but if I have to explain SDN to someone who is a Star Trek fan in one word, the BORG collective will explain how the central SDN controller will make use of the data plane of switches. Besides the fictional race of the Borg's let me explain SDN with a real world personal example.

Many of us, unfortunately, are used to getting into a traffic jam on a daily basis on our way to work.

My office used to be five miles off of the freeway and it used to take more time to travel those five miles than the ten miles I travelled on the freeway. One day I was running a little late for work, but to my surprise, I had actually arrived at work about 5 minutes early. When it happened again the next day, I realized that all the traffic lights (see diagram below) had been timed such that if you are travelling at the speed limit you will get a green light all the way through. The city had not only coordinated and timed the lights, but had also increased the times of the North-South green light by about 15 seconds while reducing the East-West light times by 15 seconds during peak hours of traffic. This was great for me and other drivers. It did not have any negative impact because the East –West traffic was minimal during peak hours on week days.
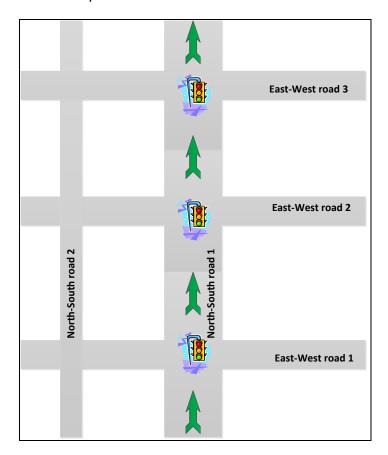
Figure 2.0

All was good until people noticed that the same rules applied on a Saturday or a Sunday or any other holiday. As a result, the East-West traffic was bad in the morning and evening on holidays and weekends because the lights were giving priority to the North-South traffic even when there was minimal traffic.

About two weeks after this change in lights, there was an accident during morning rush hours on the corner of E-W road 2 and N-S Road 1. (See diagram below) Because of the accident, the N-S road traffic was diverted to the side road to bypass the stretch that had the accident.
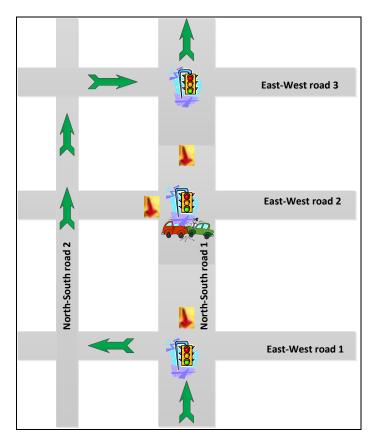

East-West road 3

East-West road 2

North-South road 2

North-South road 1

East-West road 1

Figure 2.1

This created a lot of problems because the diversion took the traffic from E-W road 1 to NS Road 2, and then back on the main road using E-W road 3. This entry back to the main road was slow by design and all the drivers were late by at least an hour or more that day.

What if they had cameras installed on all these traffic lights, they could see that the traffic light on EW Road 3 was the traffic choke point? There were no cars coming on the N-S road. That is something I could only wish for because this is a huge infrastructure investment. You need to install cameras at all the intersections and then have someone or an application monitor those cameras and change the duration of lights according to traffic.

So what am I saying with this story?

If you are thinking in terms of the following then you understand the concept of SDN.

Cars and **Trucks** = **Packets** on the network

Roads = **Data plane** of the network

Traffic **light controller** = **Control plane** of the network

Me, the **driver** in the car = the **application** (because this road infrastructure is there to facilitate my transportation)

SDN is an architecture under which the applications (me sitting in that traffic jam) can ask the management plane (traffic light controller) for a particular treatment (priority, least hops, lowest latency) across the network. This management plane has the central view (cameras installed at each intersection) so that it can dynamically direct traffic depending on the congestion and multiple paths.

SDN formal definition

I thought that it would be wrong if I do not give you a formal definition of SDN. However this turned out to be no trivial task. There are numerous definitions out there but not all the players agree on one definition. Since Open Networking Foundation (ONF) (www.opennetworking.org) now manages SDN, I will give you their definition.

"Software-Defined Networking (SDN) is an emerging architecture that is dynamic, manageable, cost-effective, and adaptable, making it ideal for the high-bandwidth, dynamic nature of today's applications. This architecture decouples the network control and forwarding functions enabling the network control to become directly programmable and the underlying infrastructure to be abstracted for applications and network services."
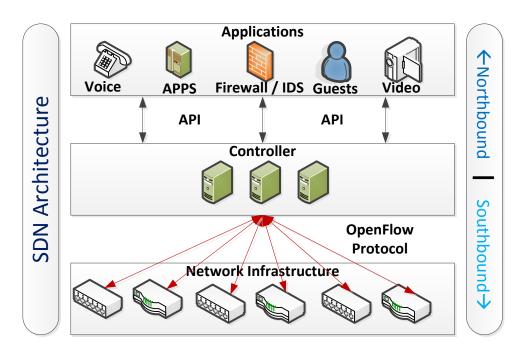
Figure 2.2