Software Defined Networking

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Introduction

This report will cover the topic of “Software-Defined Networking”, also known as SDN. The area of specific discussion for this report will be SDN and how it relates to Cloud Computing. The report will contain an introduction to what Software-Defined Networking is, an introduction to cloud computing, and a comparison between the two. Throughout this report examples of SDN in the real world will also be looked at, as well as a look into the future and what it holds in relation to SDN and cloud computing. A focus will be put on showing the similarities of Software-Defined Networking and Cloud Computing.

Discussion

What is SDN?

Software-Defined Networking is an approach to networking that strays from traditional network management in favour of a systematic and programmatic approach similar to that of cloud computing (Benzekki et al., 2016). To better understand this it is prudent to explain network management also. Network management itself refers to the process of administering computer networks. This administration could include troubleshooting of errors and issues, the installation and management of new hardware, and performance analysis. Various tools exist for the purpose of network management, largely for the purposes of monitoring, mapping, and configuration with tools such as InterMapper (Nance, 2007). Though it has limited relevance to this report, the field of network management can also include cybersecurity, with applicable tools being ones such as Wireshark or Splunk (Harris, 2020). To further explain SDN; its purpose is to reduce the workload induced by traditional network management methods. The SDN method seeks to centralize relevant data into a centralized platform allowing simpler modification and data access (Montazerolghaem, 2020). This aforementioned centralized platform is commonly referred to as an “SDN Controller” (Lessing, 2020). Finally, the SDN architecture consists of 5 key elements, directly programmable, agile, centrally managed, programmatically configured, and open standards-based / vendor-neutral ("What is SDN?", 2020). To elaborate on these points, agile means the architecture allows for abstract control to meet specific needs easily. Centrally managed refers to that the SDN must be managed through a central point with a global system view, i.e the SDN controller. The requirement that it be open standards-based and vendor neutral means that the SDN will have simple interaction with various applications and hardware based on open standards shared across vendors.

What is Cloud Computing?

In order to fully understand SDN we must also understand something closely related to it, cloud computing. Cloud computing refers to the on-demand ad-hoc provisioning of computing resources such as storage, virtual machines, and network resources (Ray, 2018). This works in such a way that many users, typically companies, access a shared pool of computing resources and pay for what they use. The goal of cloud computing is to remove the dependency companies have on physical hardware, which can be costly to maintain, both in terms of hardware, and the expertise needed to maintain operation. That however is not to say that cloud computing doesn't require expertise to effectively implement, cloud computing requires skilled implementation to effectively lower costs for a company (Wray, 2014). This lowered cost is also achieved through the reduction of overhead, for example, with cloud computing you are only paying for what you use. If you only utilize 50% of a physical server, the other 50% is wasted, compared to cloud computing where you just pay for that 50%. Cloud computing is considered to be Infrastructure as a service (IaaS), the goal of which is to manage networking, storage, servers, and virtualization for the user/company (Mell & Grance, 2011). Popular examples of existing cloud computing services are those such as Microsoft Azure, and Amazon AWS. Cloud services such as those aforementioned are often including new services within their platforms; a recent example of which would be Microsoft's release of Azure Machine Learning (Miller, 2015).

An exploration of the networking capabilities and features common among cloud computing platforms will also be prudent, due to its specific relevance to the topic at hand. Cloud computing platforms allow users to entirely abstract the network connectivity between various applications, workloads, and virtual machines and seamlessly integrate them with existing IT infrastructure. For example, one could connect two separate on-prem subnets through an Azure virtual network, utilizing various existing tools such as Azure Core or ExpressRoute (KumudD, 2021). One thing of note is that with cloud computing, topography is purely logical, the physical location of various resources is seldom a concern, as the topography is heavily abstracted to the user, such that they only need to worry about logical topography. However there are existing use cases that justify the need for dictating aspects of physical topology. For this purpose, within tools such as Azure there are features allowing some control over physical topology. For example, one such tool would be Azure's ExpressRoute, which allows a private and physical connection to azure datacenters (Duongau, 2021). Features such as this are valuable in situations where even small variances in latency are business critical, or where strict security compliance is being upheld. Finally, cloud computing platforms allow for abstract VPN connectivity between cloud and on-prem resources, through existing tools such as those in Azure (Cherylmc, 2021).

Overall cloud computing provides an array of tools largely focused towards enterprise and education. The goal of these tools being to limit overhead related to maintaining physical hardware and providing a better way of tying cost to the use of resources. Cloud computing, especially in relation to networking, abstracts concepts for users without removing functionality. For example, removing the need to concern over physical topology, while still allowing full customization of logical topology. Or, allowing the creation of vlans within the cloud environment, simplifying deployment and allowing network admins to take a more scalable and agile approach. Finally, it should be noted that the cloud is seeing exponential growth, and offerings are subject to change ("*The global cloud computing market,"* 2021).

SDN vs Cloud Computing

When comparing software-defined networking and cloud computing it should be noted that they are compatible systems and methods. SDN can be considered an element of cloud computing, as the features of cloud computing often fit the definition of SDN. However, SDN can still be deployed without the use of cloud computing, but this is uncommon (“*SDN and Cloud Computing,”* n.d.). The reverse of this is that cloud computing can also be implemented without SDN, however this is even more uncommon. This is because cloud computing is often implemented in enterprises of a large scale, manually managing the networking of various resources, such as VM’s would be extremely tedious and difficult. Thus software-defined networking principles are often followed with cloud computing implementation. SDN compliments cloud computing as well as existing problems such as those relating to federation can be addressed with SDN principles (Azodolmolky et al., 2013). While SDN can be used in conjunction with cloud computing platforms, it should also be noted that several different approaches may be prudent depending on a given organization's situation (Linthicum, 2019). For example, a private SDN deployment would mean the SDN is running exclusively on local/on-prem hardware. To contrast this, a public deployment is the opposite, where the SDN runs exclusively within a cloud computing platform, such as Microsoft’s Azure, or Amazon’s AWS. There are pros and cons to each approach, such as the scalability provided by cloud based SDN, or the security and control provided by private. However these two options aren’t totally exclusive either, a hybrid implementation is also possible, where part of the infrastructure is cloud based, and the other part is located on-prem (Kameshwar, n.d.). This approach is beneficial because one can tailor their infrastructure to their enterprises needs. For example, having more latency critical systems locally, with more seldom ones in the cloud. An additional point in which SDN and cloud computing find synergy is through being abstract and agile (Rosencrance et al., 2021). Agile, in this instance refers to the ability for rapid provisioning and deployment of resources to meet company needs (Shukla, 2021). For example, if a certain VM is a bottleneck due to a lack of allocated resources, it’s possible to quickly allocate more resources, or clone the VM to meet the needs of the enterprise. SDN in this case, is also agile, in that it allows on-demand and expedited changes to be made to an enterprise's network, in relation to a traditional non software-defined network. Finally a point can be made in highlighting that as the trend of moving into the cloud continues, the distinction between cloud computing and SDN networking may blur. It has been previously established that SDN can be implemented without cloud computing, however this may become impractical as an increasing amount of enterprise infrastructure is hosted in the cloud (Shirer, 2021). To further clarify this point, SDN’s purpose is to simplify the maintenance and deployment of current and future network infrastructure by abstracting a network into an SDN via an SDN control plane (Hassas Yeganeh & Ganjali, 2012). This however can be accomplished through cloud computing as it has the ability to abstract network resources, allow agile deployment, and programmatic configuration. Within smaller enterprises or organizations cloud computing may not be a practical requirement, especially if there’s limited need for compute resources. In cases such as these, the need for SDN is also limited. If SDN were to exist in an enterprise like this it would likely be because the enterprise or organization has their IT requirements fulfilled through an outsourced MSP (Managed Service Provider) which itself will implement SDN on a macro scale among its clients (Gillis & Moore, 2021). Or, alternatively, implements cloud computing which by its nature is likely SDN (Sahba, 2018).

Conclusion

To conclude this analysis of software-defined networking and its relation to cloud computing a review of major points will proceed. First, SDN was shown to be a distinct approach to networking in comparison to traditional concepts. This is because SDN prioritizes a programmatic, agile, and centralized approach to networking which allows swift modifications to be made in an enterprise environment, lowering the workload of admins and turnaround time on projects. As an example, the programmatic approach enabled by SDN allows templates of optimal or compliant infrastructure to be made and implemented, without concerns over specific details in physical topology, or configurations on a micro scale. A look into cloud computing also took place, in which the aspects of it were analyzed and deconstructed. Cloud computing is typically considered as IaaS (Infrastructure as a Service), this is because it provides IT infrastructure such as, networking, storage, servers, and VM, as a pay-per-usage service (Boisvert et al., 2020). For example, with traditional on-prem infrastructure, the enterprise is in charge of maintaining hardware, and ensuring maximum value is extracted from owned hardware. While if that same enterprise were using a cloud computing solution, they would only pay for the resources used, so they wouldn't need to worry if a server is at 50% usage, as this is abstracted from them. Next, within this report, a comparison among the two concepts, cloud computing and SDN was performed. It was discussed that SDN is often contained within cloud computing, as cloud computing fulfills many of SDN's ideals, but also that SDN can exist separately from cloud computing. It was also touched on that although SDN can exist independently of cloud computing, SDN will likely eventually become an element of cloud computing completely, as cloud becomes the standard in enterprise and education environments. Finally a brief note was made of the fact that smaller enterprises and organizations lack the need to implement cloud computing or SDN, but that in the case their IT requirements are managed by an MSP, it's likely they do have implemented SDN or cloud computing.

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