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# Software Defined Netconomics

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## Abstract

This paper is based on the fair analysis on the economic benefits of software defined networking. The paper will explain vividly the concept of software defined networking and its applications together with the economic advantage(s) with respect to both the client perspective and server perspective. In general, SDN provides lower hardware and operational cost in an excessive traffic load of nowadays users. It has tighter security and faster response time with improved management and planning of server controller. SDN when deployed provides better service(s) with respect to lowering cost and of course with better efficiency. Software Defined Network (SDN) is a great revolutionary idea to change IT Industry of which includes cloud computing and many others. The beauty of its architecture is the decoupling of the essential control and data planes from the application layer, thus the underlying infrastructure is abstracted but the network intelligence is logically centralized with state. This architecture gives access to the enterprise to control, program, automate, scale and secure the network according to the business needs, together with securing a safe benefit in competiveness that has risen due to fast advancement in technology. This architecture is even more important to fulfilling the demands of various clients in the current model of networking. The concept of SDN has the potential to change the current networking model. With SDN, for network services, the underlying network infrastructure can be abstracted by the administrators for many applications. In theory, it can be shown that SDN has many benefits over current IT systems but in practical systems, IT companies are reluctant to work with, tend to oppose nor are they ready to deploy SDN. In this paper, the economic benefits are explored and discussed without bias, and it will be shown that new protocol of SDN provides many economic benefits and guidance to IT companies to establish more secure and efficient network.

**Keywords:** Software Defined Networking; Decoupling of control and data planes; Economic Survey

## 1. Introduction

N modern age of technology, high bandwidth, quick accessibility and dynamic management are the modern trends in the IT domain [1], in particular, in mobile, social, cloud and big data [2]. Rich multimedia contents are getting popular in users and this increasing demand for big data is demanding high bandwidth and higher network connection speed than ever. For example, the data centers have been hit by a large “north-south” client server traffic due to excessive

use of social TV [3]–[7] and Ultra High Definition (UHD) television and big data analytic applications. To collect input data and to combine the output results, large “east-west” inter server traffic has been triggered in data centers to partition input data and combine output results.

On the other hand, to fulfill the social needs of user(s), it is a demand of ubiquitous and reliable communications in a wide range of mobile devices and social networks. This demand is increasing day-by-day with the number of users increasing. Interestingly, the number of mobile connected devices has been noted to exceed the number of people on earth by the end of 2014 [8]. It has been predicted that by 2018 there will be nearly 1.4 mobile devices per person [9].

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A dramatic growth is also been observed in social networks in recent years. For instance, a social media site Facebook expanded from 1 million users in December 2004 to more than 1 billion active users in October 2012 [10] which is more than 200% expansion per year.

Although the current Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) is the self-managed service [2], and they are providing a high level of automatic configuration in the system, but due to demand of more computing and storage space and fast communication link, it is becoming critical to access these resources via a fast network due any remote access area to fulfilling today's computing needs. To overcome these dramatically in increasing demands of the networking user, the newer and advanced protocol with new features and reliable fast speed is required. SDN seems to have answered the call of this demand and is ready to provide the most reliable and advanced method to operate the things properly.

With the advanced features of SDN, it is expected and one might guess easily that SDN must be a well understood concept and it has been easily accepted by the IT companies and they are using it for their own benefit and for giving better services to the user. But the reality is completely different, in the survey result of 2012, which was managed by Information Week 2012, it was shown that only 4% of the IT companies have begun to use SDN and only 5% of the companies are testing it [15]. This is also the case in 2016 too. The reasons of this narrow adoption of this protocol even with very strong advantages can be that this protocol is not a narrowly defined protocol such as TRILL or SPB but rather it is a complete different approach of handling the server and it's focus on the centralized control functionality. [11] The IT companies are reluctant to start this approach due to its completely different approach and the companies are thinking of its benefits in long term services and its economic efficiency. This report will present the economic benefits of this network to provide the basic guideline to help IT organizations to develop some strategy to adopt SDN in their services in long term benefits and to develop better programming interfaces in network equipment.

## 2. Definition, Explanation and Benefits of SDN

In this section, a short introduction and definition of SDN is provided. In literature, Software-Defined Networking (SDN) is the name of an emerging network architecture in which network control is directly programmable and network is decoupled from forwarding [12]. Considering this definition, SDN has two important characteristics, namely decoupling of data and control planes, and direct programmability on the control plane. These features are not new in network architecture. There are many different protocols which are based on these features, as detailed in the following.

Firstly, the programmability of network was promoted in many different methods. One example is the SwitchWare [13] in which the concept of active networking is deployed. This concept controls a network in a real-time manner using software. Similarly, Click [14], XORP [15], Quagga [16], and other software that are used in routing suites on conventional PC hardware have also attempted to establish programmable network devices to make extensible software routers.

Secondly, the feature of decoupling between control and data planes has been acknowledged during the last decade. The software that includes this feature includes Routing Control Platform (RCP) in 2004 [17], this protocol replaces the inter-domain domain routing protocol GPP with the centralized routing control to simplify the distributed path computation.

The uniqueness of SDN is based on the fact that it provides both of the features at higher rate. It provides programmability through decoupling of control plane. It is simpler and it provides simplicity in the current complex active networks. Moreover, SDN provides an advanced feature of separation of control and data planes in the network architecture which was not possible in any other protocol [18]. Figure 01 is showing the general block diagram of SDN reference model [19].

SDN provides a number of advantages to the user in a variety of ways in many networking devices, applications and software. These benefits are delivering substantial growth to both enterprises and carriers in different aspects of the network, including centralization and better management and control of networking devices through multiple vendors, improvement in the management of the common APIs and better control to the underlying layer details by abstracting the underlying layer from the application. It is also beneficial in providing the new network capabilities without any manual configuration of device. It energizes the rapid innovation with minimum efforts in configuring the routers by going at user's home or wait for the vendor's releasing notes. The underlying layer is abstracted and can be modified anytime without configuring every device individually. This benefit brings a lot of economic stability to the vendor as well. Its other benefits include better programmability by operators, increased network reliability, better security with minimum chances of error in configuration.

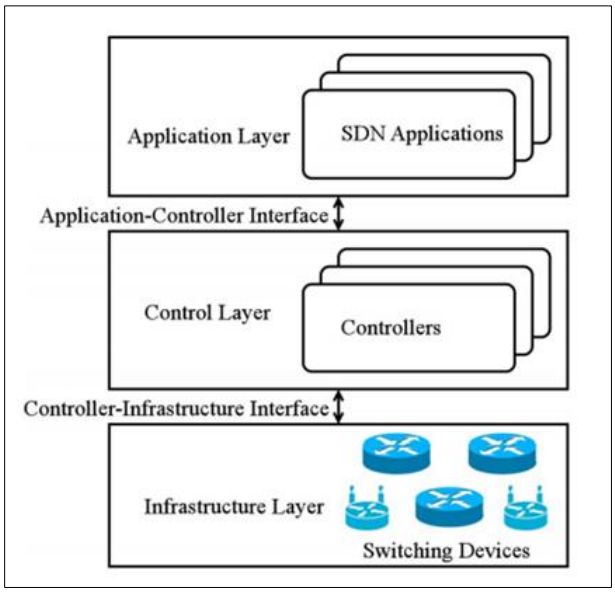


**Figure 1** Reference Model of SDN

SDN offers a number of benefits to hybrid data centers too that includes not only the simple and centralized control but also a mix of legacy, on-premises private cloud and public cloud infrastructures. These advanced features are ready to cover the upcoming more dynamic technology and is poised to automate hybrid data centers to turn them into efficient control units. The main benefits of SDN are in the key areas of security and agility. The presented business use case is generic and so far, provides the safest method to secure the data center and achieve more reliability [14,15].

To achieve most efficient end point security system, SDN helps to build a "zero trust network". With SDN, a secured physical or virtual end point is attained on day one. Then, whenever someone attaches the end point to a network, it will only be able to communicate with other whitelisted devices. No device will be trusted in SDN until it is verified. This will allow users to access all their resources in a secure manner regardless of their location. In addition to enabling zero trust networks, a comprehensive policy framework can also be managed by SDN much more efficiently. For example, without SDN, every data center was needed to be implemented with a security policy and an engineer would need to implement a security policy to multiple devices within the data center one by one. As, these devices can vary from one type to other which causes a very lengthy and more error-prone process to configure all the devices one by one with this proposed method. With SDN technology, a policy can be created which can be pushed uniformly across all the data centers in an instant of time. This makes it easy to secure the whole system.

## 3. Business Case of SDN

After discussing the benefits of SDN in the section above, three use cases of SDN are discussed in the following sections to justify the business case and economic benefits for SDN. These use cases involve service creation, WAN Network Virtualization and Network Analytics. Service Creation use case is for inserting desired pipeline of services like firewall, or IDS in the automated traffic steering network based on SDN. WAN Network Virtualization use case provides an Open Flow overlay to an existing L2/L3 VPN-IP network among data centers, while network analytics includes an SDN approach for traffic replication to the analytics network. It allows the WAN to use an Open-Flow overlay or passive optical taps. The analytics Network uses Open Flow for traffic filtering and replication to multiple analytics tools. [29,33]

### 3.1. Service Creation and Insertion Use Case

This use case automates the traffic steering to achieve a desired pipeline of services. It also customizes services to meet each customer's specific needs. Figure 02 illustrates the network configuration for this use case [29,33].

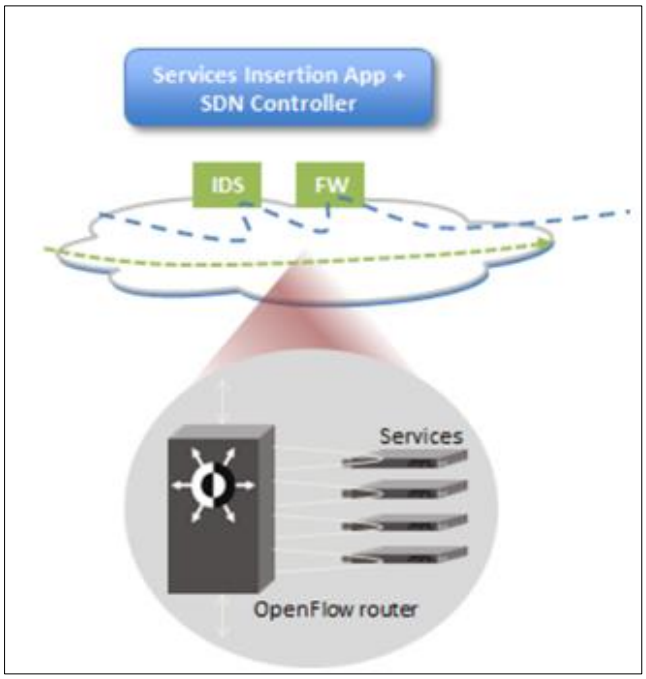


**Figure 2** Network configuration

The network consists of an Open-Flow-enabled router that steers traffic to IP services. The routing and commands to configure the routers are provided by the SDN controller and service insertion software. There is no need of CLI and other manual services because standardized APIs support automation of the service creation process. Standardization eliminates the use of disparate vendor-specific EMSs to control the individual IP services. Optimization of the use of network resources has also been achieved by this configuration by eliminating the need to steer traffic through the IP service appliances. This increases the traffic utilization of the router and on each IP service appliance. It also reduces I/O port requirements that ultimately reduce the cost. Finally, service velocity is increased and much faster service delivery is achieved at significantly lower service order processing costs.

### 3.2. WAN Network Virtualization use case

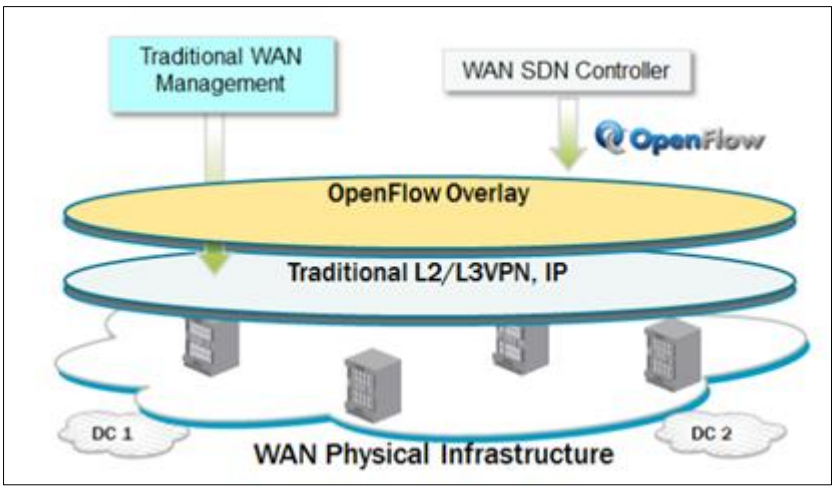


**Figure 3** WAN Network Visualization

Figure 3 provides an overview of the network architecture that also explained the use case with a sequence of overlay layers [33]. In this design, the existing network is provided an Open-Flow overlay and associated WAN SDN controller [33]. The traditional traffic is not affected by the Open-Flow and does not affect traditional traffic. Certain protection is provided in hardware and a hybrid port mode is created. This setting will allow the operation with reduced risk to ongoing operation and will make maintenance easy during deployment of the initial Open-Flow overlay service. As,

there is an advantage of SDN that it can handle an increasing traffic share network, thus, capacity additions are reduced because SDN provides better network usage visibility. To achieve higher capacity at utilization level, method include SDN will provide more routing flexibility [32-33].

The cost of the system will also be reduced due to centralization of network control in the SDN controller. It allows the use of lower cost line cards in each WAN router.

### 3.3. Network Analytics Use Case

Figure 4 illustrates a network analytics use case for a mobile operator [33]. Network analytics are used to provide real-time network statistics for collection and alerting [29,33]. Its applications include summarization of normal and abnormal traffic, detection of network performance issues in advance of customers' complaints [33,34].

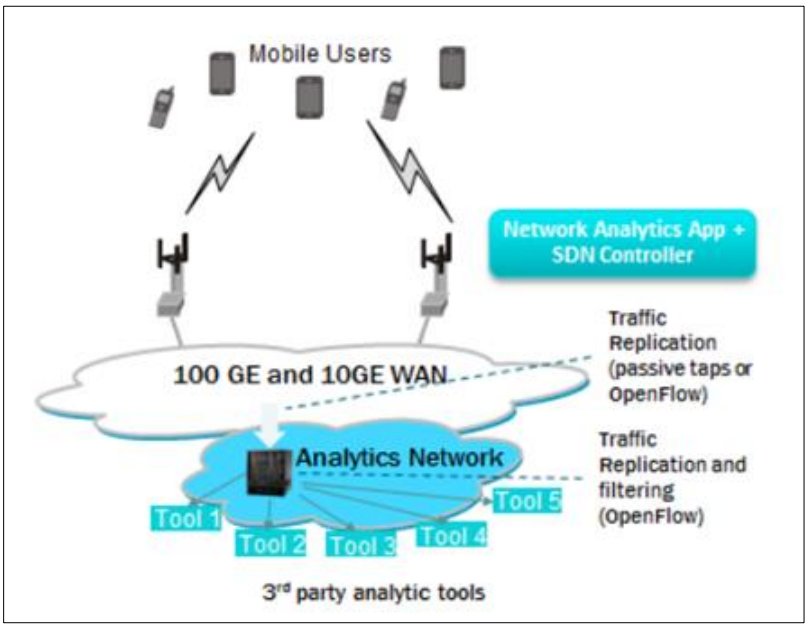


**Figure 4** Network Analytics

For achieving these goals under SDN, the WAN uses an Open-Flow overlay for traffic replication to the analytics network. To provide traffic filtering, a centralized network analytics software application and SDN controller use an Open-Flow router and replicate to multiple analytic tools. The Open-Flow router in combination with the network analytics application and SDN controller optimizes the use of network resources. It eliminates the need to steer traffic through the network analytics tools and provides real time information without impacting the production network and users. Centralization of the processing function in the SDN controller allows lower cost line cards to be deployed in the router[32-33]. It reduces overall network cost and increase the service velocity which results in much faster service delivery and much lower service order processing costs.

## 4. Economic Survey

In this section, the economic benefits of SDN will be provided with the help of real world data to encourage the IT companies to deploy their current system towards SDN. SDN provides many economic benefits to the system which includes better power usage and energy efficient operation using the concept of Green Networking.

Green networking is becoming important designing the network for economic and environmental benefits. There are different approaches to achieve green networking which includes energy-aware data link adaptation, proxying of traffic in energy efficient way, energy-aware infrastructure and energy-aware application. [21] Although switching devices including SDN may not provide the best energy reduction in network operation, but it can provide a great minimization on the energy consumption in the whole network. SDN experts have proposed a mechanism to calculate minimum switches and data links for a network based on the number of users. SDN also included dynamically power down redundant links to save the power. This mechanism can save power by its energy efficient operations. [22]

Another economic advantage of SDN is its relatively simple design of switching device that will have a separate control plane. These switches are very easy to manufacture using merchant silicon and its cost will be much cheaper than any other switching module. [23]

Another feature of SDN is to provide a platform to implement various SDN applications. For making better and efficient network operation decisions, a global network view can be obtained through SDN applications. These applications can also have cross-layer information that can decide the dynamically redundant paths and low power paths intelligently. At infrastructure layer, the SDN controllers make decisions properly to ensure economic, social, and environmental benefits. These all features that provide economic balance as well as social benefits with better performance of SDN controllers.

Despite these charming economic advantages and innovative disruption and comprehensive explanation of how charming SDN basically is, the economy has a bad effect of SDN too. Recent victim of its negative impact is cisco. Cisco is a burning platform but due to SDN's concept of mirrors broaden and virtual servers based on software which is controlling underlying hardware, Cisco is disrupting and losing its strong economic benefits due to the virtual nature of routers, no real cabling. Companies like Cisco, Aritsa and Juniper that are traditional stranglehold networking vendors are struggling to adopt SDN due to its un-stranglehold nature. [24-25]

## 5. Quantitative Economic Analysis of SDN

After discussing the basic overview of economic benefits and disadvantages of SDN qualitatively based on many different performance characteristics of SDN, in this section, the quantitative analysis of SDN will be done based on certain parameters and a comparison will be done between a classical scenario which includes a distributed network structure and an SDN model which is centralized model decoupled from data and control planes. Before doing this, a rigid definition of cost is needed to be defined in terms of CapEx and OpEx. CapEx is the measure of fixed infrastructure of any company while OpEx is based on rented infrastructure. Although they are interconnected but they have different impact on the economy of the company while maintaining any tool or provide any hardware service to the users. In this sense, the cost comparison can be done on the following merits:

- Capital Expenditures
- Operational Cost
- Repairing Cost
- Service Cost
- Installation Cost

Under the comparison phase, the SDN switches are less complicated and devices are cheaper as compared to distributed traditional design. Thus the SDN devices will be cheaper and will decrease the *capital expenditures,* however the extra devices such as Open-Flow controller or line cards will increase the expenditures slightly but with the benefit of resource sharing and better control and aggregation of traffic handling, SDN will always have less capital expenditures than traditional model but the improvement is still needed to further reduce these capital expenditures.

*Operational Cost* is the running cost of the system, which is undoubtedly lower for SDN because it simply do not require any extra power or cooling devices at the control level as the system is centralized and there is no load on the control level. Furthermore, SDN gives a better control over traffic and resources utilization that will also reduce the power consumption of the device thus this quality also belongs to SDN as compared to the traditional system.

The next test is the *repairing cost* which can be reduce by SDN. By proper standalone testing of the devices, the devices can be made bug free. Furthermore, the resource sharing property will also be useful in this section too, because one device can share the load of other device by proper handling of the traffic. It will reduce the repairing cost and significantly reduces the signal point of failure of the network [25-28].

The cost of services is also lesser for SDN as compared to other network models because SDN provides the feature of autonomous enabling of the devices and auto-configuration of the switches from centralized control unit. There is no need to go to distant area to configure any new router. The person at the centralized unit will configure the router of distant location without going to its location [26]. The reduction of the mobilization has reduced the service cost of SDN system.

The last test to be held for the quantitative analysis is its starting cost and the first time installation cost which is surprisingly much lesser than existing model for SDN. SDN has created innovation at a higher level to achieve a faster speed and higher frequency of debugging, installing and testing any device. SDN environment is easy to be simulated and there is always a path of debugging any bug before transition of existing model to SDN. With the simulator, the staff members can be trained to start working at the operation center on the real domain while testing the system in the simulator. In this way, the training, testing and installation will go in parallel and it will significantly reduce the installation cost of the system. These five quantitative parameters have shown that SDN has clearly an upper hand on the economic benefits over all other existing networking architecture. This quantitative analysis can be modeled with the help of the figure shown in Fig. 04. [26]

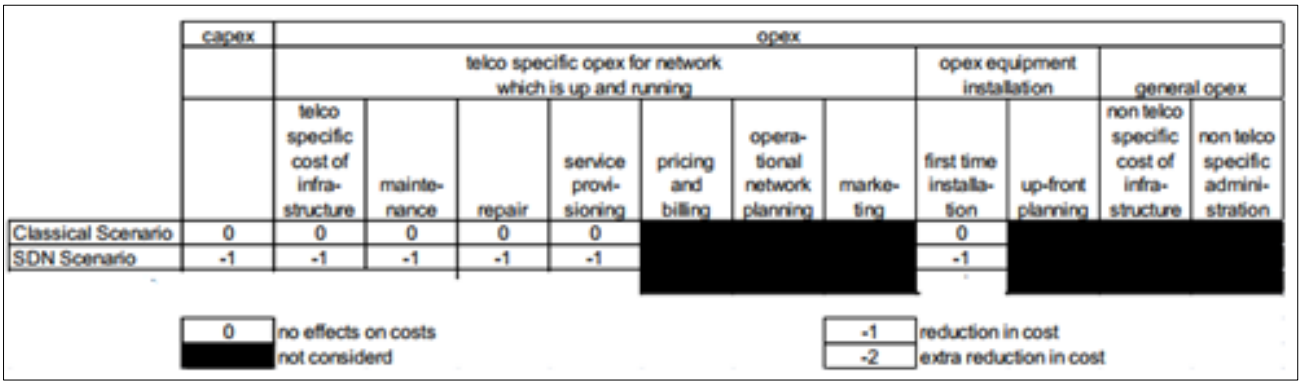


**Figure 4** Quantitative Analysis of SDN

## 6. Discussion

After describing so much about SDN and its real time applications, implementation and economic benefits of enterprises who are providing these services to the users, it can be marked as SDN is no longer only the part of course curriculum. It has become a reality in many fields now. Enterprises are now ready to take off to the new highs with SDN and they are more than ready to absorb all the economic and technical benefits of SDN. SDN has revolutionized the world of networking from organizing and configuring all the routers manually and individually to just changing the knobs and dials at the command centers to attain ever-fastest rate with the benefits of resource sharing, decoupling, centralization, large bandwidth and many more. The user and service provider are at much ease by adopting SDN and the enterprises are earning benefits of this revolution. This thing can be easily seen from the fact that the estimated revenue of worldwide cloud services in 2016 through SDN and many other models is close to $73 billion which is 4-folds more than that of 2011. From this $73 billion, the share of SDN is more than $2 billion [26]. The revenue of SDN was $200 million in 2013 and 10 times growth rate in just 3 years has indicated a fast turn-around in the IT domain. [27-32]

In 2011, SDN was just on paper. IT companies were reluctant to adopt this system but in the span of 5 years, from zero to $2 billion is a rapid growth and a significant achievement in IT market forecast. To show a bigger picture based on facts and figures, the report of Allied Market research [32] have suggested that the SDN market is likely to reach $132.9 billion around 2022 and beyond, considering the growth rate of 47% from 2016 to 2022. This growth rate is achievable for this modern tool because the implementation of SDN is increasing day by day across industries due to its advanced features as discussed throughout this paper. This report also revealed that SDN was accounted for around 47% of the global market revenue in the service providing in the year 2015. While for the installation of new network, SDN has earned 43% of the global revenue in 2015. In this race of revolution, North America is the first on the list which includes highest revenue generating places for SDN. Many big IT companies like IBM have given a billion dollar price tag to SDN for coming years which proves the significance of it in simple words.

## 7. Conclusion

A comprehensive survey of SDN is provided in this paper including its introduction, definition, advantages, and applications. The most economical, secure use cases are provided for the fresh-entrepreneurs and current share-holders, which are willing to adopt this system in their current model. The quantitative analysis is done in which comparison of existing system is done with SDN under five different merits; at the end the future expectations are discussed. It is concluded under literature review that SDN is the future and it is getting mature to earn a strong place in the competition of different architecture models of IT industry.

## Compliance with ethical standards

*Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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