

A Survey on Software Defined Network Plus White Box Switching

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Abstract: *Emerging mega trends like “social media, mobile devices, cloud computing” are pursuing the traditional network to their limits. With the help of Internet, a digital society is creating but the conventional static architecture is ill suited for dynamic computing. The explosions of “mobile devices and content, server virtualization and use of cloud services” are the new trends of networking industry that forces the traditional network to re-examine architecture. Today’s networking paradigm is changing continuously and it is very difficult to re-configure traditional IP network. The current networks are vertically integrated: that means the ‘control’ and ‘data’ planes are bundled together. The traditional approaches are based on manual configuration so it is cumbersome and error prone, and also the physical network infrastructure is not fully utilized. ‘Software Defined Network’ is an emerging architecture that is most promising solution for future and can change the state of affairs. Software defined network is “dynamic, manageable, cost-effective and adaptable”. It gives us a solution of handling high bandwidth, working with big data. It gives us the flexibility to work with open standards. The goal of the SDN is enabling cloud and network administrators to respond quickly changing requirement through a ‘centralized control console’. White Box Switching is the ability to use generic, off-the-shelf switching technique and routing hardware in the forwarding plane of SDN. White Box Switches supports a variety of development tools, several automation capacities and it let the developers to focus on networking process. Open flow is used to program the forwarding table of white box switches by SDN controller. White box switches are also flexible so it supports a range of open source management tools. Why white box switches are best suited for SDN is the main purpose of this paper. In particular, we will focus on the ‘design of white box switches’ and ‘control platforms’ – on aspects such as “resiliency, scalability, performance, security and dependability”.*

Keywords: Software defined network, White box Switching, Dynamic computing, Programmable switch, Centralized server

1. Introduction

The architecture of conventional network is not properly suitable for dynamic computing. The explosions of “mobile devices and content, server virtualization, and use of cloud services” are the mega trends of networking industry that forces the traditional network to re-examine its architecture.

Emerging mega trends like “mobile, social media, cloud computing and big data” are urging computer networks for “high bandwidth, omnipresent accessibility and dynamic management”. Communication networks have grown in size so “complexity, efficient architecture and implementation to reduce costs, simplify management, improve service provisioning time and improve resource utilization” has become increasingly important. First, as the popularity of rich multi-media contents are growing and demand of big-data analytics increases, data sources are demanding higher network Connection Speed than ever. For example, social TV and Ultra High Definition television bring “north-south” client-server traffic flood to data centres, and big-data analytic applications like ‘MapReduce’ trigger large “east-west” Server-to-Server traffic in data centres to partition the input data and combine the output results. Second, a wide portion of the mobile devices and social network is demanding more frequent communications to fulfil the social need of today’s generation. Social networks of today experienced a dramatic growth. And Cloud Computing has added further demand on the “flexibility and agility of computer networks”.

Conventional networks make full utilization of special algorithms and make full implementation on a device that are dedicated, for controlling and monitoring the data flow in the network, and manage “routing paths” and determines how different devices can be interconnected in the network. A conventional network utilize special algorithms implemented on dedicated devices to control and monitor the data flow in the network, and manages routing paths and determines how different devices are interconnected in the network. The key technologies that allow the information to flow are routers and switches. Despite of widely adoption traditional IP network are “complex and hard to manage”. Nowadays the control plane and the data plane are bundled inside the networking devices what is called vertically integrated. This reduce the flexibility and hinder further “innovation and evolution” of the network infrastructure.

Software-Defined Network is a rising design that is **dynamic, reasonable, financially savvy and versatile**. It gives us an answer of dealing with high transfer speed, working with enormous information. It gives us the adaptability to work with open guidelines and it is dynamic in nature.

As Software Defined Network (SDN) is making appearance as a networking paradigm, it gives hope for changing the limitations of current network infrastructure. First, the vertical integration is break by separating the network’s control plane from those underlying routers and switches that used to forward the traffic. Second, by separating the control and data planes network switches become simple forwarding devices.

One of the key challenges of SDN is how the programmable switch can be achieved as mentioned in the paper “Are We Ready for SDN? Implementation Challenges for Software-Defined Networks” and one of the arrangement of this issue can be White Box Switches. As White box switches utilize superior equipment that acknowledges an assortment of systems administration working frameworks. The biggest difference between it and traditional Ethernet switches is that software of with box switch does not dependent on its hardware. In white box switches, users can choose the hardware and operating systems from different a vendor that gives the flexibility to work with different platform and different types of data. Flexibility is provided by White box switches to choose hardware and software. As for SDN, it simplifies network design and operation by providing instructions through the SDN controllers instead of multiple, vendor-specific devices and protocols.

2. SDN: Definition, Benefits, Characteristics and Algorithm

A. Definition of SDN:

The “Open Networking Foundation” (ONF) is a non-profit consortium that is dedicated for “development, standardization, and commercialization” of SDN. ONF provided the most explicit definition of SDN as follows:

In “Software-Defined Networking” (SDN) the network control is decoupled from forwarding plane and is directly programmable.

SDN is defined by two characteristics, namely “decoupling of control and data planes”, and “programmability on the control plane”.

SDN results in improving network performance in terms of “network management, control and data handling”. SDN has a potentiality to solve the problems faced by Conventional network and that’s why it is gaining more acceptances in the applications such as Cloud Computing. It can be used in “data centres and workload optimized systems”. By using SDN, the administrators can be able to control the data flow as well as it can alter the characteristics of the “switching devices” (or routing devices) in the network from a central location. Without dealing with each device individually by using control application all characteristic can be.

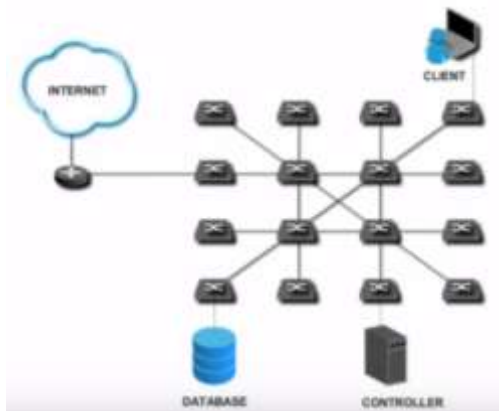


Figure 1: SDN Scenario

B. Benefits of SDN:

SDN, with its use of decoupling with control plane from information plane, offers a more prominent control of a system through the programming. This consolidated component would bring potential advantages of upgraded setup, enhanced execution, and supported advancement in arrange design and different operations. For instance, the control grasped by SDN may incorporate bundle sending at an exchanging level as well as connection tuning at an information interface level, breaking the boundary of layering.

1) Enhancing Configuration: In arrange administration, design is a standout amongst the most imperative capacities. In particular, when new gear is included into a current system, appropriate arrangements are required to accomplish intelligible system operation all in all. The manual arrangement strategy is monotonous and blunder inclined. In the meantime, noteworthy exertion is additionally required to investigate a system with setup mistakes. For instance, on the off chance that we take an internet shopping framework if every one of the requests are handle physically then their undeniable blunder however in the event that the errand is finished by a solitary controller then it should be possible legitimately.

2) Improvement of Performance: In arranging operations, the key goals are to augment use of the contributed organize framework. Be that as it may, inferable from concurrence of different advancements and partners in a solitary system, streamlining execution of the system in general has been viewed as troublesome. Current methodologies frequently concentrate on streamlining execution of a subset of. SDN takes into consideration a unified control with a worldwide system see and an input control with data traded between various layers in the system engineering.

3) Encouraging Innovation: within the sight of proceeding with development of system applications, future system ought to empower advancement as opposed to endeavour to unequivocally foresee and superbly meet prerequisites of future applications. In SDN we can undoubtedly include new capacity and that will be work with no issue.

C. Characteristics of SDN:

Software Defined Network is an approach for computer networks that allow the network administrators to “initialize, control, change and manage” network behaviours dynamically via open interfaces.

The characteristics of SDN architecture are:

- **Directly programable:** Network control can directly programable as it is decoupled with forwarding functions.
- **Agile:** Abstracting of control allows the administrator to adjust the wide network traffic flow dynamically.
- **Central management:** Network intelligence is centralized in “software-based SDN controllers” that maintains an all-around view of the network.

- **Programmable configuration:** SDN allow network managers to “configure, manage, secure, and optimize network resources very quickly” through dynamic, automated SDN programs.
- **Open standard base:** SDN simplifies the network designing and operation because instruction is provided by the SDN controllers rather than vendor-specific devices and protocols.
- **Enabling innovation:** SDN allows organizations to create new type of “applications, services and business models” that can offer new revenue stream and add more value to the network.

The main goal of the “**Software Defined Network**” is enabling Cloud and network engineers to respond to the quick changing requirement through a centralized control console. SDN is designed with multiple kinds of Network Technologies that makes it more “flexible and agile” that supports virtualization of server and storage infrastructure.

3. SDN Architecture

In SDN model there are three layers, namely an “infrastructure layer, a control layer, and an application layer”, stacking over each other.

The **Infrastructure Layer** consists of several switching devices (e.g., “switches, routers” etc.), which are connected with each other to form a single network.

The **Control Layer** combines the “application layer and the infrastructure layer”. SDN Control Layer consists of four main components, namely a “high-level language, a rule update process, a network status collection process and a network status synchronization process”.

The **Application Layer** stack above the “control layer”. Through the control layer, SDN applications can easily access a global network view with instantaneous status through a “northbound interface of controllers”.

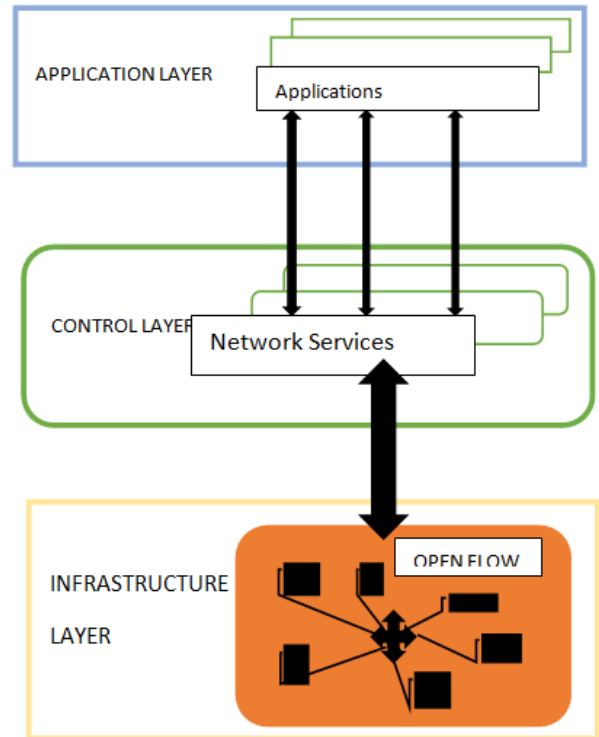


Figure 2: Software Defined Network Framework

Working guideline of Software Defined Network:

Regardless of giving a wide choice of contending design SDN strategy brings together control of the system by isolating control rationale to off-gadget PC assets. The working guideline of SDN is:

- **Controllers:** As we can likewise say the "cerebrum" of the system, “SDN Controllers” offer a unified perspective of the general system and empower organize executives to manage to the basic framework.
- **Southbound APIs:** SDN utilizes Southbound APIs to hand-off data to the switches and switches underneath.
- **Northbound APIs:** SDN utilizes “Northbound APIs” to speak with the application and business rationale above.

Why Software Defined Network now?

Online networking, cell phones and distributed computing are seeking after conventional system their points of confinement. Process and profit by amazing advancement in virtualization and mechanization, yet those advantages can't be utilized because of the impediment of systems.

Programming Defined Network can possibly change the control of system by giving adaptability so it can work more like virtualized variants.

A portion of the key registering patterns driving the requirement for another system worldview include:

- **Changing activity design:** Comparing with customer server application where the main part of the correspondence happens between one customer and one server, today's applications get to various database and servers. At the interim clients are changing system movement designs as for the access to corporate substance

and application from any gadgets and mists, coming about extra activity over the wide region organize.

•**Working with "Enormous Data"**: Handling today's "huge information" or uber informational indexes requires monstrous parallel preparing on a huge number of servers associating with each other. This builds interest for extra system limit in the server farm.

•**The ascent of Cloud administrations**: Enterprises now grasps both open and private cloud administrations. Undertaking specialty unit now need the readiness to get to application, foundation and other IT assets on request. To add to the multifaceted nature, it's making arrangements for cloud administrations must be done in a domain of expanded security, consistence and reviewing necessities alongside business acknowledgment.

As point by point above, "Software Defined Networking" offers a few advantages for organizations attempting to move into a Virtual Domain. There are a huge number of utilization cases that SDN offer for various associations, that includes transporter and specialist organizations, Cloud and server farms, and also undertaking grounds.

D. Calculation:

In SDN when a customer needs to get to the database or need to send information to another gadget it has to take after a few stages or we can state that the information transmission is occur in a few stages. It isolated into two isolated planes one is control plane that controls execution and stream administration. The second one is information plane which is in charge of sending activity to the goal.

Step1: When a host needs to send information to another host the customer initially sends demand to the control plane and the switches decide if it should be possible locally or need to request that the controller what do.

Step2: The switch sends a demand by the control convention to the brought together controller.

Step3: When the controller sends an affirmation to permit the transmission in view of the ip-address, the controller likewise makes an association table and afterward makes a best way through the programmable switches.

Step4: Then the spill out of a host to have is started; a switch is in charge of sending compliance when a transmission is finished.

Step5: The switches can likewise make way however locally and interfaces with Internet to transmit information without including controller.

As switches are in charge of interfacing gadgets it should be programable and for this programmable switch White Box Switches are most appropriate.

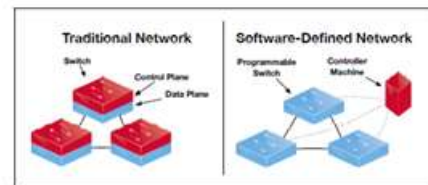


Figure 3: Traditional Network vs Software Defined Network

For example, consider a task of maintaining a Spanning tree that connects the several switches in the network. Such a tree can be used for forwarding broadcast traffic without any danger of forwarding loops. The traditional or classic way for building a spanning tree is to use the Spanning Tree Protocol in which the switches exchange information periodically with their neighbours using pair wise announcements. But when the topology changes the time to calculate a new tree scales with the size of "longest loop-free path". Most SDN controllers provide a suite of common functions that comes in many applications such as "topology discovery and link fault detection" which makes it simple to implement spanning tree. Whenever the topology changes it simply computes a Spanning Tree from the topology using "Prim's algorithm" and installs rules on switches and forward along the tree.

4. White Box Switching

White box switch is a term used to portray its commoditization gadgets by gathering off-the-rack parts. At the point when utilized as a part of the setting of exchanging, open exchanging equipment stages are made utilizing off the rack processor, memory and exchanging chipsets which are perfect with different producer's product working frameworks. The idea of white box has been championed by end-clients who request an incentive without yielding execution and in the register and capacity universes has turned out to be very effective. It is the systems administration industry that is presently voyaging this same commoditization way and as of now conveying initiative items. Remember that item equipment requires a working framework that exploits the equipment's abilities and which eventually conveys particular capacities. In the server world, Linux and Windows have a tendency to be the two most mainstream decisions, and it is the product working framework that really decided the qualities acknowledged by the end client. In the exchanging market, it is the white box working framework again that decides the abilities that the end client gets.

Definition of White Box Switching and White Box Switches

"White box" changes allude to the capacity to utilize 'non-specific' off-the-rack exchanging (or white box exchanging) and directing equipment, in sending plane of a product characterized organize (SDN). "White box switches" are truly quite recently that – 'clear' standard equipment. They speak to the foundational component of the ware organizing environment required to empower associations to pick and pick the components they have to understand their SDN destinations.

“White box switches” depend on a working framework (OS), which may come as of now introduced or can be acquired from a product merchant and stacked independently, to coordinate with the conveying association's Layer 2/Layer 3 topology and bolster an arrangement of fundamental systems administration highlights. A typical working framework for “white box switches” is “Linux-based” in view of the many Open and Free Linux devices accessible that assistance chairmen alter the gadgets to their necessities. Conventional Switches produce and keep up their own particular sending and directing table that can, as a rule, communicate to neighbouring switches and switches. A white box switch may come pre-stacked with negligible programming or it might be sold as an uncovered metal gadget. The benefit of this approach is that switches can be tweaked to meet an association's particular business and systems administration needs.

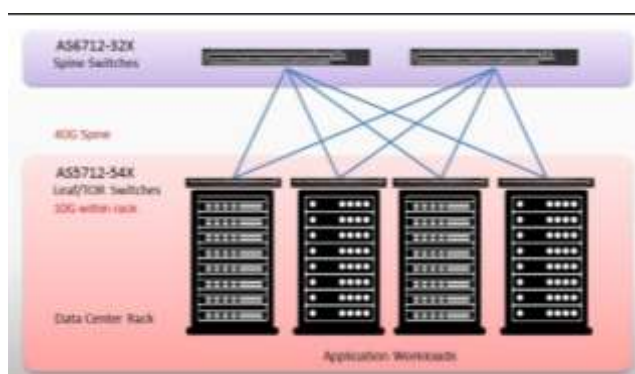


Figure 4: White Box Switches

White Box Switching in SDN Environments

Inside a SDN domain, the applications running over the SDN Controller are what give the larger amount coordination and programmability of the system. The “SDN Controller” utilizes “OpenFlow (or another southbound API)” to program the sending table of the “white box switches” and direct how to course associations with finish the proper assignments for the applications. Since they are so adaptable, white box switches an additionally be utilized to help a scope of open source administration devices, including OpenStack, Puppet, and Chef.

Some industry spectators have scrutinized the market capability of white box exchanging, noticing they are likely appealing to associations who are hoping to remove an incentive out of their framework and drive incomes, versus the individuals who are running the system as an instrument and IT cost. Cases of sellers offering white box switches incorporate Acton, Celestica, and Quanta Computer.

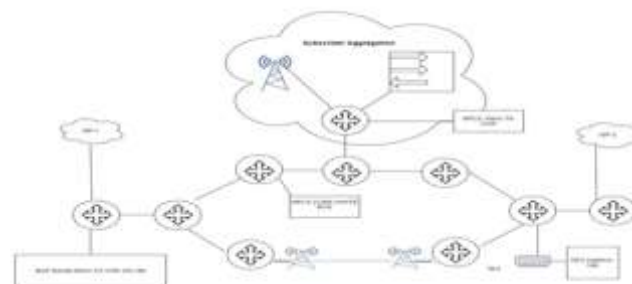


Figure 5: White box switches in SDN environment

White box organizing alludes to the capacity to utilize “non-specific, off-the-rack switches and switches inside the sending plane of a product characterized arrange (SDN). Consider white box organizing and switches as a clear standard that gives clients the foundational equipment element(s) of a system”. The typical working framework for WBS is based on Linux operating system, because of its extreme accessibility of tools which are free and open to everyone.

“WB (White Box) changes vary from conventional switches and switches in their absence of knowledge; while customary switches and switches produce and keep up their own sending and steering tables, white box switches can't do this”. In software defined networks conditions, application over the software defined network controllers offer this larger amount insight by utilizing “open flow to direct association courses and assignments”.

If we take the example of online shopping when a customer request for a particular item the controller sends requests to all the intermediate switches. And as white box switches can work with open flow it gathers information about the item from all the warehouses are sends to data to the customer by the shortest path. In this way white box switches makes the task easy for the network and decreases the overhead to the controller.

Advantages of White Box Switches:

Despite the fact that existing conditions of white box switch isn't so acceptable, it won't square and cloud its prospect of advancement since regardless it has a great deal of favourable circumstances overweighing its detriments.

1. Cost: To be completely forthright, most vertically coordinated exchanging and directing stages are stacked with highlights the vast majority of customers will never utilize. Besides, a considerable lot of the highlights that customers need to utilize come at a high cost. So, they regularly need to pay additional costs for these highlights. In any case, the general cost of white box switch is lower than those marked gear, since it evacuated a few highlights that buyers once in a while utilized and mark premium too.

2. Quality and Simplification: Notwithstanding this value advantage, a few buyers would view white box as modest mediocre products, which turns out a misconception. Since the organizations making equipment are proficient OEM processing plants. Their nature of switches is tantamount to marked switches. Indeed, even the brands of equipment

are their OEM. In other words, white box is keeping pace with mark name frameworks since they are really a similar equipment. Aside from the quality, white box switch does not include confused capacity, and they just make work sets required by target buyers. For instance, they are more averse to include MPLS VPN, ISSU Etc. Rather; they concentrate on moderately basic and controllable server farm, particularly SDN switch. It rearranges programming and makes it comprehended to generally clients.

3. Highlights and Capabilities: White boxes regularly are utilized as a best of-rack switch or as a feature of a SDN organization. They bolster industry measures, for example, OpenFlow. Furthermore, they are exceptionally programmable and work with arrangement instruments, for example, Ansible, Chef and Puppet. Additionally, white box switches are described by solid telemetry capacities and transparency with the goal that system managers can get whatever data they requirement for whatever reason. Truth be told, around there, most would agree white boxes are regularly better than customary layer 2/3 switches.

Algorithm of how White Box Testing done:

Both developers and the tester use White box. By white box testing we can actually understand which line of code is currently running. The next switch is selected by using the white box switching technique.

Step 1: "Understand the functionality of the application through its source code".

Step 2: Creates the tests and execute them.

There are 3 main WBT techniques:

1. Statements Coverage
2. Branches Coverage
3. Paths Coverage

Let us give a brief description with examples.

1. Statements Coverage: Actually, "statement is the line of code in programming language or instructions for which the computer will act accordingly". Statements like comparison are the best example of statement coverage as it will cover all the instruction under the comparison.

2. Branches Coverage: "Branches in programming language is like if statements. If statements have two branches true or false". Similarly, in transmission when we want to send data if the connection is true then use branch coverage.

3. Paths Coverage: Path coverage tests all the paths of the program. This is a comprehensive technique which ensures that all the paths of the program are traversed at least once. Path coverage is even more powerful than branch coverage. It will follow the program flow until all the conditions are explored.

Role	CPU Requirements	Memory Requirements	Disk Requirements
Network Controller (OpenFlow)	4 vCPUs	4 GB for 2 GB recommended	75 GB for the OS drive
Control Plane Node	8 vCPUs	8 GB recommended	75 GB for the OS drive
SDN Gateway	8 vCPUs	8 GB recommended	75 GB for the OS drive
Single point of the network gateway for traffic and control	2 vCPUs	2 GB	75 GB for the OS drive
SDN Gateway (OpenFlow)	2 vCPUs	2 GB	75 GB for the OS drive
OpenFlow Controller (OpenFlow)	2 vCPUs	2 GB	75 GB for the OS drive

Figure 6: Requirement of SDN

White Box Requirements:

- "If we separate this into more detail, there is truly four noteworthy segments that make up a system switch".

- **Silicon:** "This is exchanging chip that pushing bundles and edges through the system. The silicon will have some arrangement of capacities that it can perform rapidly", for example, forward an IPv4 parcel as indicated by a sending table, channel activity by means of an entrance list, organize movement as per an approach, epitomize and decapsulate movement utilizing burrowing conventions, et cetera.

- **Box:** This is simply the equipment body with a power supply, circuit board, cooling fans, Ethernet ports, and so on. Somebody must make the crate. As an aside, Rob said going by an assembling office abroad where he saw indistinguishable switches marked with two unique merchant's emblems and transported out the entryway. He was making the point that not all equipment is distinctive within on the grounds that there's a name making individuals agreeable outwardly.

- **Network and Operating System:** "There must be programming sitting on the container that makes it conceivable to program the silicon in the case to accomplish something. That is the activity of the system working framework and low-level quality driver".

- **Application:** The applications are the daemons running on the working framework giving frameworks organisation.

•Manufacturers

- "QuantaQCT-Quanta QCT is a branch of their computer department, Inc.; they are makers of the case."
- "Acton-Acton is another creator of "the crate".
- "Delta Networks-DNI is yet another producer of the crate".

5. Conclusion

Software Defined Network has discovered a new way to manage with update programmability within its own structure to help the idea of its upcoming limitations. "Also as transmission restrict request lifts, the arrangement of extra limits and "preparing electricity with help for different 100GE channels will be unsurprising through a

SDN-based resuscitate and besides overhaul". SDN guarantees adaptability, joined control, and open interfaces between focus focuses, empowering a fit, versatile structure. With a specific genuine goal to satisfy these objective, distinctive extraordinary difficulties must be settled. In this article we have exhibited a trade of various inconveniences in the extent of "execution, flexibility, security, and interoperability". Present Industry examination and industries game-plans can resolve some of the issues which are facing, and diverse working get-togethers are in like way talking about potential designs. Regardless of these, the mix program planning might be a way to deal with execution and some issues shown by SDN. The aim of this model is to push stream dealing with in the structure.

The conceivable fate of structures will be conformed to this improvement. The objective is to give reasonable trades and associations where system, information, and considering are intertwined along with advantage building. Later on, for a particular strategy, information will ask for the taking care of, storing up, and connection it requires before moving the application. The scope of the structure fragments may be scattered physically and in each handy sense, however this will be completely diminishing to the end client. All the client will watch is the possibility of development of the asked for organization. SDN will add to this vision of future trades. Regardless, colossal issues must be tended to meet needs. No doubt in the world, thought of the potential for application-driven systems may lead us to consider whether software defined network as right now imagined is also adequate. Everything thought of it just like, sure that SDN is digging in for the entire arrangement as a developmental move, impacting arranged toward exceedingly streamlined unpreventable association to layout.

In addition, to vanquish a couple of inconveniences of SDN we have "White box testing for security is very useful and it's also economical". It has all the capabilities to handle all the errors of the previous methods used. Compositional and arrangement levels danger examination give the "perfect setting to try and perform the white box testing". It can also be used with revelation testing to make improvisation in general tests ampleness.

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