International Journal of Scientific Engineering and Applied Science (IJSEAS) - Volume-1, Issue-6, September 2015
ISSN: 2395-3470
www.ijseas.com

Viability of SDN Implementation For 4G Networks in India

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Abstract

The current scenario is that internet has paved way to the creation of a digital society wherein almost everything is connected from anywhere. But the main concern of the day is that heavy traffic makes it very difficult to manage with the age old traditional networks. It is difficult not only in configuring the networks as per the predefined policies but also to make the network enable in handling the heavy load. Current networks are also vertically integrated, that is, the control and data planes are bundled together- this is making the situation even worse. Software-defined networking (SDN) is an evolving paradigm that changes the current scenario. It breaks the vertical integration and separates the control logic from the underlying network elements.

Another concern that exists these days is the speed of the data networks. In order to retain the customer, it is very essential that a customer enjoys high speed connectivity, faster connection times, less round trip latency. The eventual and ultimate goal is to make super-fast and highly reliable connectivity available anywhere. This is achieved by 4G LTE technology. The transition of 3G to 4G has been taken place only because of the speed. With 4G LTE, it becomes very comfortable and pleasurable using the web from phone as using it from home computer.

LTE networks are growing fast worldwide. But along with that the network management challenges also come along with it. The idea of SDN combining with LTE is proposed by this paper as it could be a game changer with the centralized control for the network. SDN's capabilities are able to address many difficult challenges faced while implementing 4G networks. With 4G Enabled networks, load increases and some mechanism to manage this load of high speed networks is needed. We need interoperability as in 4G LTE, everything is 4G LTE including voice calls. While moving to higher technologies like 4G, no. of elements/components are less and everything is in managing these few network elements. Hence here, the need of a control plane to manage the data plane and the plane that interacts with the customers is felt. This paper talks about the gap in today's networks and why it is a good idea to implement SDN with 4G LTE.

Keywords: SDN, Speed, networks, 4G LTE, control plane

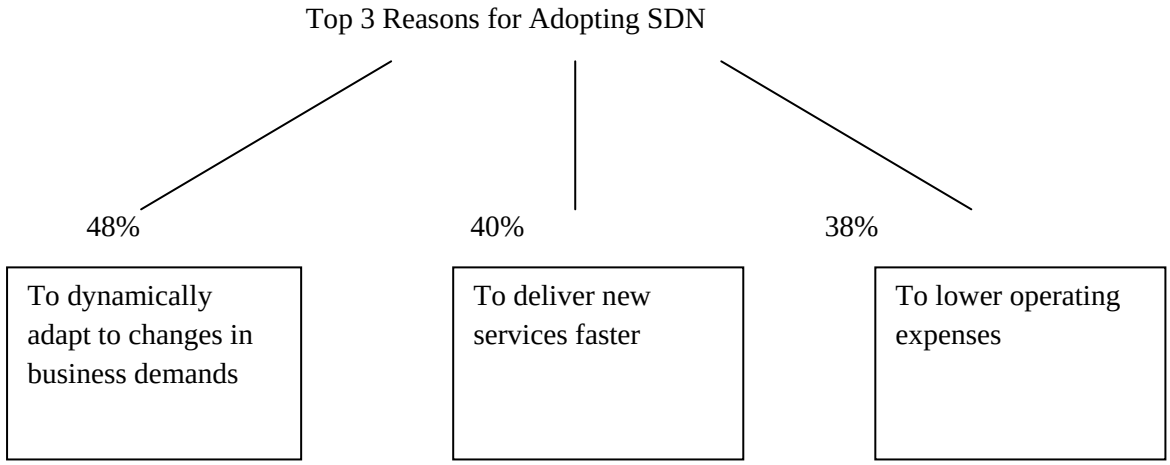
1. Introduction

The software defined networking (SDN) market will touch $25B per annum by 2018, and could touch $35B annually. [1]Network Technologies are not agile and compatible with the growing demand of the business.[2] SDN willfulfil the gap of the traditional network architecturesand will meet the requirements of present enterprises, carriers, and end users. [3] It is a new approach where the network's control and forwarding planes are being separated for better optimization. SDN has picked up all the control part from the different network elements and centralised the control.

1.1 Need of SDN

Currently in India, the SDN market is at an emerging stage. Globally, the SDN market is estimated to grow to $2.1 billion in 2017 from $198 million in 2012, the CAGR being 60%. [4] The need of SDN is evolving with the increasing requirements of the business.SDN implementation opens up a means for new innovation and new applications.This introduces scope for network-wide access control, power management, and home networking, for which the network view is not beneficial but absolutely necessary. [5] Furthermore, the network programmability possible in SDN allows seamless communication at all levels, from hardware to software and ultimately to end users.

The carrier SDN and NFV market is expected to touch USD $11B by 2018. [6] Here lies the real opportunity for Indian Telco Operators. However; to help operators differentiate their services;flexible virtualized architectures, leveraging SDN and NFV is required.



1.2 Benefits of SDN

The benefits of SDN's implementation cannot be ignored. There's been a lot of talk on SDN; so far; but few implementations actually. But the benefits that are provided by the SDN cannot be ignored. Some of the benefits of SDN to an organisation are:

a) Efficiency and lower operating expenses:

Administrators using SDNs have sold the technology to their executives as a money-saving methodology. Lower hardware costs are a big selling point for SDN. However, the bigger opportunity is lower operational expenditure costs due to improved network management efficiency.

b) Virtual network services, lowered capex:

With the introduction of SDN technology, enterprises can lower their capex by either making efficient use of what enterprises have already or by decreasing dependency on proprietary hardware and appliances.

c) Better and more granular security:

Security is one of the important benefits that SDN offers to the IT industry. With virtual machines coming into picture, it becomes difficult to monitor the system. SDN, thus, can provide tailor made security for applications, end nodes and BYOD devices that a traditional hard-wired network can't provide.

d) Deliver Speed, Agility and flexibility:

Data centers and the traditional networks are being stretched out of their limits and were not designed with the vision of current humongous growth in the bandwidth intensive applications—and the always increasing demand for scalability, speed and resilience. SDN forms perfect solution for these challenges.

2. Use of SDN

As a technology, SDN has emerged as a solution thus having different roles throughout the network. There have been varied cases where SDN technology has been proposed to tackle emerging network problems. We have discussed few cases thus exploring the role of SDN in the networks.

2.1 Use of SDN in improvising the existing networks

It is forecasted that the global SDN market for the enterprises and cloud service provider would grow from $360 million in 2013 to $3.7 billion by 2016 [17].Introduction of Software Defined Networking (SDN) is changing the operator's network. The design and network operations are modified in order to achieve business agility. With SDN, it has become very easy to program [7]. Also, networks are open and no longer proprietary. They are transformed into an open and programmable component of the cloud infrastructure. SDN provides network owners and operators largercontrol of their infrastructure.This allows customization, optimizationand reducing the CAPEX and OPEX. It also helps service providers to create new revenue generating opportunities by creatingsoftware-based applications.

86% of operators are confident about deploying SDN and NFV technology in their optical transport networks [18].Operators are interested in SDN concepts to increase provisioning agility in revenue generating service and reduce service time to market. The onslaught of exponential growth in

connected devices after the implementation of technologies like IOT or M2M, in multiples of tens of billions by 2020 leaves them no other options to evolve [19]. Operators who are still not into this are also eager to take profit from cloud computing.

The following figure gives a clear picture of how to use SDN in improving operators.

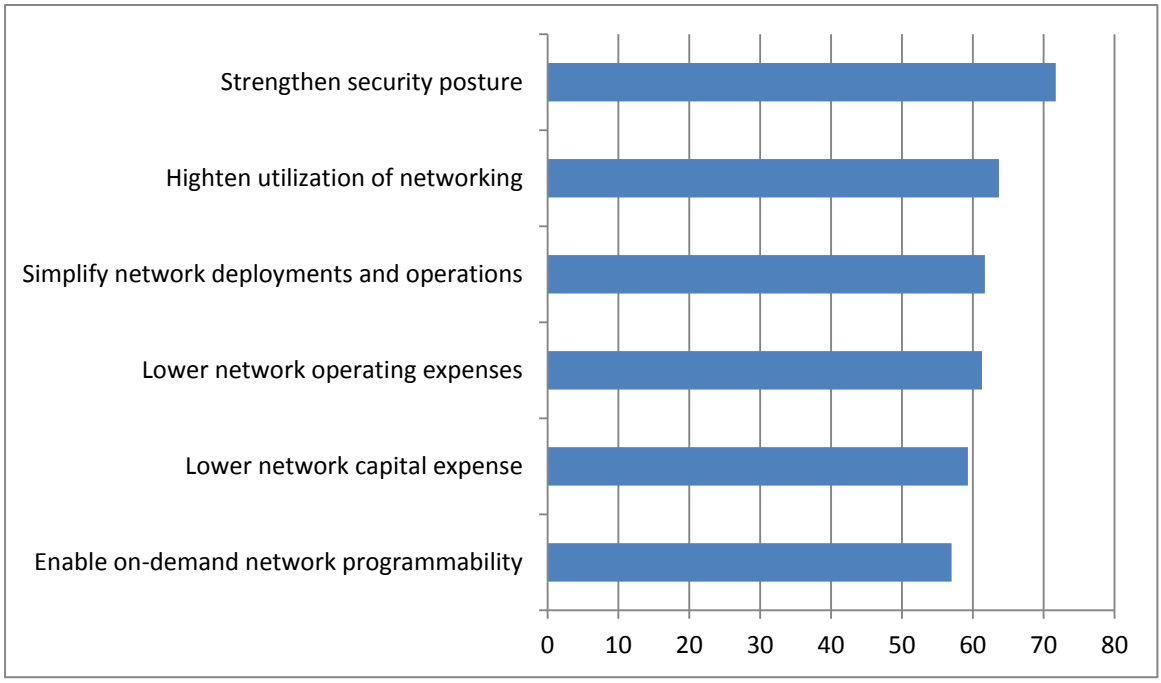


Fig 1: Benefits of SDN to Operators

2.2 Use of SDN in seamlessly and consistently managing the converged networks

A large majority of companies (77%) are expected to turn to their existing networking vendors for their SDN hardware (switches and routers), and also 63% of the operators are expected to go to them for controllers [21]. Networks are converging. Variety of services like Voice, video, and storage and data are already converged into one network.Hence the advantage of the current networking is to tackle these virtual networks, mobile devices and cloud services. The next available solution is software-defined networks. It is very difficult to manage and monitor in converged networks. But SDN into the operators' networks makes everything simple as it provides the control part centralized. [9] Subscriber expects a variety of services from the operator but in a very less time. In order to meet up to this requirement there is a need to have a central control plane and the data planes would forward the data as per the instructions of SDN Controller [9].

Hybrid SDN is the best optimized solution for using existing network equipment and an architectural approach to provide the IP fabric for the SDN controlled network connections in the data centres [10]. The advantage of this approach is the central management and control of the network paths over the existing network, which leads to a more efficient network platform and network assets achieve an extended lifecycle. With this hybrid SDN environment, an enterprise can utilize SDN as well as standard switching protocols on the physical hardware simultaneously. Hence, operators would now

be able to save their capital expenditure on standard switching. It is possible to configure the SDN control plane to discover and control traffic flows. Rest of the traffic on the network will be directed by the traditional, distributed networking protocols.

2.3 Use of SDN in Data Centre

Data centre consolidation has been done already by 63% of the enterprises [22]. Also the data centres have reached a limit. With time, complexity has increased in the network while making an attempt to accommodate the growing number of applications. Hence, a solution is essential in order to make progress.

The data centres are emerging as highly virtualized environment that should address a diverse set of user needs, which includes access to data anytime anywhere, the consumerization of BYOD and increased dependency on cloud services. Security concerns are the biggest barrier to this data centre transformation [22]. While protecting user data is of prime importance, mobility and virtualization are new threats that must be resolved. The human factor leads to unnecessary downtime, expense, and unauthorized intrusion. [12]

2.3.1 Attributes offered by OpenFlow-based SDN that are best suited for implementing a secure and controllable environment:

a) The flow paradigm is suited for security processing as it offers an end-to-end alongwith service-oriented connectivity model which is not bound by traditional routing constraints

b) Effective performance and threat monitoring across the network is taken care by the centralized control

c) Granular policy management is based on application, service, organization, and geographical criteria rather than physical configuration

d) Resource-based security policies helps in managing diverse devices which are prone to threat risks like highly secure firewalls and security appliances to access devices

e) Programmatic control provides flexible adjustment of security policy

f) Flexible path management achieves isolation of intrusions and doesn't impact other network users[15]

With a central SDN solution, the network routing can be customized more easily as well, shaping it to the specific interests and needs of that data centre. Whether a company is seeking high-performance computing, Web 2.0 or cloud provisioning from its data centre, SDN enables a tailored network experience that will increase speed and flexibility, thereby encouraging innovation.

SDN can be adapted to any equipment type, such that it is vendor-neutral [15]. As long as there are common SDN interfaces to the devices in the network, it does not matter to the applications who provided the hardware or which operating system is being used. By using algorithms to create a

solution, SDN relies on OpenFlow, Puppet, and other protocols to remain agile and flexible, as well as cost-efficient.

2.4 Use of SDN to provide API platform to develop applications

Here is the study on the use of SDN to provide API platform to develop applications that run over the operators' networks and utilize some of their inherent telecom and IT capabilities.

Software-defined networking (SDN) is the latest approach to abstracting network elements, with the aim of making the network more "programmable" while also exposing once difficult-to-reach network control functionality to applications and service innovators. Open application programming interfaces (APIs) are critical aspect of the SDN story, supporting the abstraction and decoupling of the network layers and the orchestration of SDN functions acrossthem. [13]

In the future, communications service providers (CSPs) expect to create application-specific slices of the SDN; the application-defined network; where an eligible application can instruct the SDN through APIs to configure itselfaccording to the application's quality of service (QoS), security, geofencing, routing,disasterrecovery and other business needs. The SDN will offer its network controlfunctionstoapplicationsas(API-enabled)services,whichtheycanconsumeonan on-demandbasis [23].

Many CSPs have, for some time, had API-enablement initiatives aimed atabstractingandexposingassetswithintheirnetworksasaservice(NaaS).

2.4.1 Four typesofnetworkassets thatcompriseNaaS:

a) Communication: NaaS APIs that expose a CSP's core services such asvoice, messaging and video services and composite services such as videoconferencing, IPTV, PBX/IVR, call center and unified communications.

b)Commerce: NaaS APIs that leverage the CSP's billing system and chargingcapabilities to support different types of payment mechanism, such as in-app payment, direct-to-bill, digital wallet and multiple charging models, such as pre-paid credits, volume-based charging, subscriptions and real or virtual currencies.

c)Context: NaaS APIs that access contextual information about subscribers,for example device, presence, profile (calendar, contacts, preferences, parental controls, billing history, etc.) and location.

d) Control: NaaS APIs that control aspects of the network, such as band-width, QoS, security, compression, optimization, routing, cost, availability and resilience. [12]

2.4.2 Four Capabilities for API-Enabling the Network

As open APIs play an increasingly critical role in CSPs' operation and monetization of the programmable network, CSPs will need to invest in a set of NaaS API enablement

capabilities. This set of capabilities comprises:

a) API creation: tools that help internal developers to create APIs for NaaSfunction, exposing such functions as a service regardless of underlying network technology. This platform will need strong network abstraction capabilities, supporting a wide range of legacy and IP network protocols and understanding the context and processes needed for network function manipulation and exposure.

b)API management: tools that allow CSPs to protect network functions frommalicious and inadvertent misuse. This capability governs the use of APIs at runtime, ensuring network security and integrity and enforcing CSP policies around API usage, including access control through credentials management, API versioning, API call limits, charging and participation in service compositions.

c) API monetization: an extensive payment and settlement platform thatmonetizes external partner and enterprise consumption of API-enabled services. The platform should enable them to be bundled and packaged in innovative ways to drive value from NaaS and/or specifically from SDN.

d) API presentation: a developer portal and set of tools that provide accessto NaaS APIs and which help the developer ecosystem – internal and/or external – to use them.

There is a long way to go before CSPs can realize the concept of an application-driven, programmable network. But the benefits are compelling, so there is considerable impetus behind SDN initiatives. In particular, SDN is succeeding in stimulating telecom market interest in the power of open APIs, which has been something of a niche IT development in many CSPs.

CSPs need to start preparing now for the API-enabled, programmable network revolution that will sweep through the industry over the next few years. Those that have already invested in API enablement in other NaaS domains should ensure that they exploit it fully as they plan for SDN. There will be significant synergy between these API initiatives in terms of tools, technologies, knowledge and experience of network abstraction. [13]

3. Understanding 4G

The number of 4G users in India is expected to touch 15 million by the end of 2015 [35]. Technically, 4G is “4th generation” mobile data protocol. The transition of 3G to 4G has been taken place only because of the speed. LTE is Long Term Evolution. It’s a type of 4G protocol which is used to deliver the fastest mobile Internet experience. Therefore, 4G LTE network operates at the leading edge of speed and reliability [25].

Using a 4G LTE network makes one enable to download files from the Internet up to 10 times faster than with 3G. The comparison between 3G and 4G is understood by the following chart:

3G vs 4G		
Parameters	**3G**	**4G**
Main feature	Voice & Data	Converged data & VoIP
Architecture	Wide Area Cell Based	Integration of wireless LAN (Wi-Fi), Blue Tooth, Wide Area
Frequency Band	1.6-2.5 GHz	2 - 8 GHz
Bandwidth	5-20 MHz	100+ MHz
Data Rate	385 kbps - 2 Mbps	20-100 Mbps
Access	WCDMA/CDMA2000	MC-CDMA or OFDM
Switching	Circuit/Packet	Packet
IP	Multiple Version	All IP (IPv6.0)

Comparison of 3G and 4G

With 4G LTE, it becomes very comfortable and pleasurable using the internet from a smartphone rather using it from a PC. [25].currently, 4G LTE offers a range of significant customer experience improvements over wireless technologies:

a) Higher user speeds: 4G LTE enables users to download more content than 3G in the same amount of time hence making it faster. This makes data-intensive, on-the-go downloads such as music or high-definition video streaming a reality.

b) Faster connection times: LTE requires 95 % less time to connect than evolved high-speed packet access, ensuring an “always-on” service experience. This parameter is very important as it help to improve customer experience.

c) Less round-trip latency: LTE offers a 50 % reduction in round-trip latency compared to HSPA+, making real-time applications such as VoIP, video calls, and online gaming possible. This helps to make videos calls seamless and improves online gaming experience [3]

3.1 Analysis of challenges faced by top 3 Operators in 4G roll out

In order to understand the current status and challenges in 4G implementation in India, certain use cases of top 3 operators have been taken up and studied for the same.

3.1.1 Use case - Airtel

Airtel is the largest telecom provider in India with a customer base of 200 million as of February 2015 [25]. BhartiAirtel Ltd rolled out its 4G services in the national capital region on 18th June. Currently the number of users is negligible, the 4G services offer significant improvements in data speed over

wireless devices. Airtel rolled out the service on the 2300MHz spectrum band which is acquired from Qualcomm last year. Airtel adopted TDD-LTE variant of 4G technology which promises a speed of as much as 80Mbps. Right now, the service is in the trial stage and costs the same as a 3G service. But as far as consistency and quality are concerned, there is much to be achieved and desired [27].

Challenges:

Some of the key challenges faced by Airtel while implementing 4G LTE [29]-

1. Complexity and Backward Compatibility
2. Increase in back haul's traffic
3. Unavailability of terminal devices to implement Voice over LTE
4. Regulatory challenges, that is, LTE networks across the world are being deployed on distinct frequency bands as different regulators auction different spectrum bands. Hence there won't be any common devices available for implementation of 4G LTE.
5. Chipset Compatibility
6. Return on Investment

Airtel is thinking about implementing SDN. [28] Some of the drivers for Airtel to move to SDN are:

- Service velocity (100%). Fast and quick to earn new revenue
- Simpler and easy provisioning over multi-vendor networks
- Lower OPEX
- Need more automation

3.1.2 Use case - Reliance Jio

Reliance JioInfocomm Limited is the telecom company of Reliance Industries Ltd which will start offering 4G services at the end of this year. Reliance Jio plans to launch 4G services on December 28th across 20 telecom circles in India [37]. Jio plans to provide seamless and excellent 4G services using LTE in 800MHz, 1,800MHz and 2,300MHz bands through an integrated system.

RJIL is setting up a telecom network across India to provide to the highly under-serviced India market, reliable (4G) high speed internet connectivity, excellent communication services and digital services in crucial domains such as education, healthcare, security, financial services, government-citizen interfaces and entertainment.

RJIL has made significant progress in building its LTE business, including physical network infrastructure, systems, processes, sales and distribution network, applications and services, content etc.

Challenges

1. There are very few 4G compatible devices available today and the 4G is still an evolving technology. The 700 megahertz band widely used in other countries is more efficient than the 2300 megahertz spectrum band allotted for 4G in India. Apple's iPhone and iPad and Samsung's Galaxy S4 are not tuned for RIL's spectrum.
2. The task of optimizing the network; and laying the fibre all the way to the home turned out to be a humungous challenge. And so far, almost five attempts to build a stable network that functions seamlessly on the 2300 MHz spectrum have come a cropper. So much so that it is now scrambling to meet its minimum roll-out obligations. The clock is ticking; and any failure to roll out its services by the end of this year gives the Department of Telecommunications the right to withdraw the radio waves.

3.1.3 Use case - Vodafone

Vodafone India is the second largest telecom provider with a subscriber base of 160 million as of September 2014 [37]. Vodafone India has started 4G network trials in selected areas. It will roll out fourth generation (4G) services in select towns in the second half of 2015. In the February auctions, Vodafone won spectrum of 5 MHz or more in the 1,800 MHz band in five circles: Delhi, Mumbai, Kolkata, Karnataka and Kerala. They invested Rs 8,598 crore in network expansion for 4G. [30]

Challenges:

1) Quality of service is a major challenge as catering to a huge customer-base won't be easy in the future.

2) Vodafone will need more spectrum from 1,800 MHz to provide smoother LTE service.

3) Price is a major issue as the company is under debt

Elephant Talk announced that it is fully managing Vodafone Spain's new mobile virtual network operator (MVNO), Lowi. By managing everything except the radio access network (RAN) on software, it's able to move quickly, as well as let Lowi continue to introduce new services and billing changes at a rapid clip. On similar lines, Vodafone India is planning to implement SDN on its network, but only after rolling out 4G. [31]

The following table highlights the top two major challenges that are faced by Airtel, RJIO and Vodafone respectively in 4G implementation.

Airtel	Reliance Jio	Vodafone
Complexity and Backward Compatibility	Still in the stage of setting up the network	Needs more spectrum from 1,800 MHz to provide smoother LTE service
Chipset Compatibility	Very few 4G compatible devices are available today	Price is a major issue as the company is under debt

Table to showcase the top 2 challenges faced by operators in 4G implementation

4. Benefits of SDN implementation in 4G

Some of the major benefits in implementing SDN with 4G are as follows-

a) Reduced CAPEX burden on wireless carriers:

Radio Access Network (RAN) centric Network Functions Virtualization (NFV) and Software Defined Networking (SDN) investments are expected to reach $5 Billion by 2020. Amid growing demands for high-speed mobile broadband connectivity, global wireless CAPEX is increasing, as operators' delay deployment of LTE and Network infrastructure. NFV and SDN promise to reduce the CAPEX burden on wireless carriers by eliminating cost of expensive hardware platforms.

b) Reduced OPEX:

Both technologies can decrease OPEX due to a reduction in physical space, labour and power consumption. [43]The increasing roll-out of 4G technology can lead to an increase in Software Defined Networking adoption, according to Juniper Networks [39]. Most of the companies are very keen on what software defined networking could bring to their services

c) Upgradation of the network:

Any network architecture should support SDN and 4G together even though the company takes time to deploy it and wait for a refresh before it can be implemented. Mobile operators will have to enter a refresh cycle after the introduction of 4G LTE. From the radio base stations in the network, upgrades are needed as each stage to increase the bandwidth capabilities. Those who are aiming at this refresh should also look into SDN implementation [41].

d) Reduced inter-cell interference:

SDN architecture might be a solution to the issue of inter-cell interference in an LTE environment. The exponential increase in mobile traffic has led to an increase in the number of cells in Radio Access Networks (RANs) users rely on to get an entry into a 3G or 4G network. Many cells are in close proximity of each other, leading to interference that can quickly degrade quality of service. With the help of SDN, operators can make dynamic changes to the network based on parameters such as individual flow rates or aggregate flows based on specific ports, flow duration, number of users per base station, or available bandwidth, application or IP address. [42]

Currently, SDN is a massive focus of networking companies across the globe [40]. Millions of dollars is invested into R&D of the technology that will enable network controls to be brought into single management, rather than spread over various hardware consoles.

Indian operators except Airtel are still in the stage of setting up of Telecom Networks for 4G technology in India. Hence this would be the right time for tying up of SDN with 4G technologies to ensure the right set go for 4G Technologies in India.

5. Conclusion

SDN has been a promising technology so far in terms of efficiency, security and lower cost. Now with the increase in roll-out of 4G technology, SDN is crafting its way ahead. Convergence of network is happening. In order to avoid complexities in the network architecture, operators are switching to SDN technology. This technology not only simplifies the network but also reduces the investments in the business. Moreover the operators without giving a second thought can make dynamic changes in the network based on the requirement.

In India, many operators are on verge to launch 4G services. With the kind of challenges these operators are facing, many of them are planning to implement SDN as it makes easier to develop, trial & introduce new applications & services. It is quite evident that SDN will eventually play an important role in the LTE networks. Given the massive growth and ever growing dependence on the mobile networks, it seems that the SDN's capabilities would provide crucial management and coordination capabilities that would surely tackle the difficult challenges.

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