Network Evolution through SDN

TEJAS® NETWORKS

Next generation of Network Evolution – Why Telcos should take the plunge?

5G is a revolutionary next-generation mobile network that pushes the envelope of existing transport systems. Using SDN as an overarching framework helps in meeting the stringent 5G requirements. A network with an underlying SDN architecture can dynamically route traffic on a flow-by-flow basis with improved speeds and latency. The ability to leverage the SDN framework allows software control of network elements through a centralized SDN controller. SDN routing decisions are more intelligent, compared with traditional dynamic routing protocols. A well-tuned SDN network can overcome potential catastrophic outages by intelligently recalculating data flow routes on the fly. SDN allows for tremendous scalability and dynamic provisioning. No longer will carriers need to manually expand the network when moving into new regions, or add capacity to existing areas. This paper presents how Telecom Service Providers can benefit from Tejas Networks' SDN solutions which seamlessly help in the integration of diverse network elements.

White Paper

Introduction

Digital revolution has heralded the arrival of significant demands on the traditional network architecture hitherto employed by majority of the telecom service providers. There is an explosive growth of mobile devices and cloud computing services overloading these networks. Therefore, it is imperative to optimize the utilization of network infrastructure to economically scale network capacity and reduce operational expenses by simplifying and centralizing network operations.

The exponential growth of data transfer requirements increases the bandwidth requirements of the backbone transport network. There is also a need to address shifts in service requirements that require flexible bandwidth access capability. It is vital that the next generation transport networks must provide centralized smart controls to cater to these services. Thus, telecom companies are looking to implement "Network as a Service" while continually looking for ways to reduce CAPEX/OPEX in their networks.

In the recent past, compute and storage services have benefited from virtualization. However, the conventional network architecture employed by telecom operators has been the bottleneck in realizing the full potential of virtualization. Software Defined Networks (SDN) is a promising solution that can offer the operational simplicity, performance, availability and security demanded by today's networks.

Key drivers for a SDN architecture in the transport network

- **Complex networks with multiple layers:** It not uncommon to find transport networks with multiple layers such as DWDM, OTN, SDH, Packet Transport. While each layer specializes in enabling specific capabilities, a lot of functionality overlaps. It is imperative to combine functionality from different layers to deliver services at the lowest capex and opex.
- **Varying bandwidth needs:** In the past, telecom networks were static. The backbone networks were used for interconnecting PSTN exchanges, mobile sites or interconnecting Internet PoPs. The traffic being carried was mostly voice and some amount of data. The patterns of voice calls was predictable and similarly, the data connectivity was used only to browse the internet and check mails. Hence the network and the traffic on the network was quite predictable. Next-gen networks are dynamic and have varying bandwidth needs.
- **Failure survivability:** Networks particularly in developing countries are prone to multiple failures and fiber-cuts. This is primarily triggered by construction activities (causing fiber cuts), erratic power (causing network elements to go down) or failures due to environmental factors (heat, humidity, dust). Hence the earlier paradigms of having one reserved protection path is no longer enough. Multiple failure survivability is needed.
- **Eliminate vendor lock-in:** Proprietary vendor-specific algorithms (CISCO IOS, JUN OS) perform network functions that limit flexibility and create vendor lock-in. Telecom operators now look for open standards based and vendor neutral devices/applications.
- **Ease of configuration:** The configuration setups of conventional network elements are generally not reconfigurable without a service disruption, limiting the network flexibility. With the advent of intelligent networking devices that are software programmable and Network Management Systems that offer a GUI based view of the entire network, the network configuration time has reduced from weeks to days. Real time status of the network is available to the network operator who can troubleshoot a problem or incident in a few minutes.

Network modernization through SDN

SDN is a physical separation of data and control functions enabling the network control to be centralized and programmable. This enables the network devices such as switches and routers to be lightweight and support virtualization. The centralized control enables easy configuring, monitoring, and troubleshooting of the network. The important requirements of SDN are:

- **Centrally managed:** Network intelligence is logically centralized
- **Directly programmable:** Network control is programmable because it is decoupled from forwarding functions
- **Agile:** Administrator can dynamically adjust network-wide traffic flow by abstracting the control layer. This not only provides speed and agility of rolling out new services but also reduces human errors, thus delivering a more reliable and trouble free network
- **Network analytics:** Improvement in network uptime by analysis of alarms, events, logs and metrics to derive intelligence and trends from the network to predict faults even before they happen

Emerging Use Cases

Implementing SDN For Optical Networks

Optical networks are more important than ever before given their high transmission capacities forming the basis of carrier networks. Unlike conventional data networks, optical network has the characteristics of centralized management along with separation of data and controls.

Packet Transport Networks (PTN)

To cater to the needs of greater bandwidth and better quality of service, carriers have transitioned from legacy SONET/SDH to PTN. Packet transport is available with International Telecommunication Union (ITU) approved Transport Multiprotocol Label Switching (MPLS-TP) standards. MPLS-TP is a packet transport technology that incorporates congruent paths, fault management, and network visibility. An MPLS-TP based packet transport network has a layered architecture that separates the data plane from the control plane. China Mobile deployed large scale Packet Transport Networks (PTN) in both metro networks and backbone networks, which are used to carry high quality services such as mobile backhauling and enterprise customer services. The market demand for guaranteed bandwidth, dynamic and programmable networks have posed challenges to the existing infrastructure and have presented a use case1 for SDN/NFV architecture.

Optical Transport Networks (OTN)

The OTN is intended to provide robust management features that support payload rates from 1.25Gbps to upwards of 100Gbps. The OTN delivers management functionality to DWDM networks. The major advantage of the OTN is its full backward compatibility, which makes it possible to build on the existing management functionalities available on SONET/SDH. As shown in Figure 1, OTN uses OTN Automatically Switched Optical Network (ASON) /

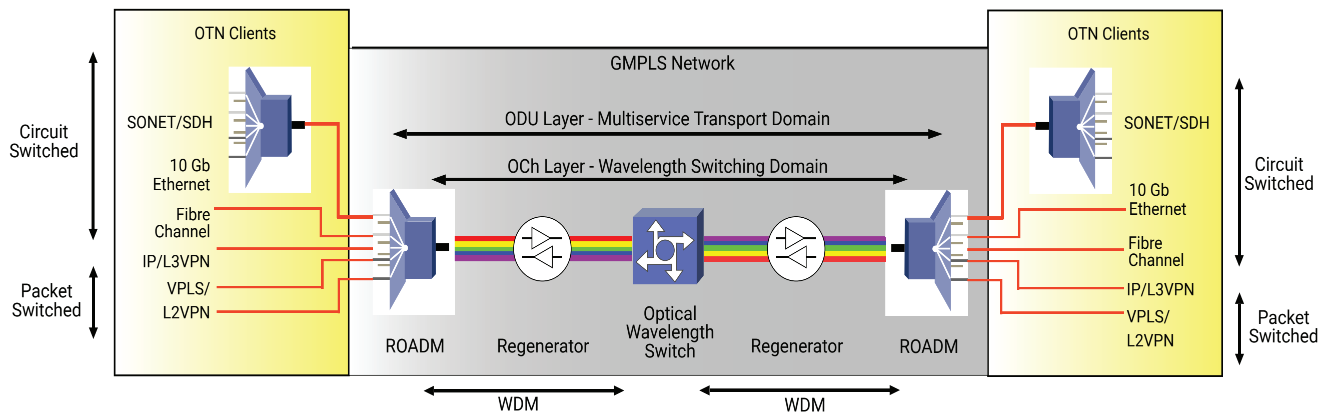

Figure 1: Illustration of G.709 OTN2

[1] Source: https://www.opennetworking.org/wp-content/uploads/2014/10/TR-538_Use_Cases_for_Carrier_Grade_SDN.pdf

[2] Source: https://www.metaswitch.com/knowledge-center/reference/what-is-optical-transport-network-otn

Generalized Multi-Protocol Label Switching (GMPLS) protocol as the optical transport control plane. The optical control plane is between the management plane and the transport data planes. The optical control plane consists of a set of applications located on each transport Network Element (NE) that enable functions such as path computation, discovery of network topologies, resources, and capabilities. Each transport NE has access to the complete network topology and resource availability to support the end service. GMPLS is predominately implemented as an overlay model.

By upgrading the optical control plane from GMPLS or MPLS-TP to SDN, service providers obtain interoperability between multiple vendors in heterogeneous transport networks and across multiple networking layers to reap the benefits of multi-layer co-ordination and optimization. This is achieved by abstracting the transport layer and presenting to a centralized controller which is a crucial element to the SDN architecture. Due to the latency involved in having a single SDN controller for the entire system, the proven performance of distributed control while borrowing the hierarchical nature of the SDN architecture with its open north-bound, south-bound interfaces and an orchestration layer to enable end-to-end path provisioning across multiple vendor domains and across multiple network layers is used.

SDN for Network Slicing

A key enabler of the power of 5G is network slicing which allows telecom operators to allocate portions of their networks for various applications such as smart home, the Internet of Things (IoT), factory automation or a smart energy grid. Network slicing allows the creation of multiple virtual networks atop a shared physical infrastructure.

Implementing SDN for CORD

Telecom Central Office (CO) consists of diverse legacy devices which are based on varying standards. Large companies operate many of these over residential, mobile and enterprise customers. The Central Office contributes to significant investment in CAPEX and OPEX for the Telecoms. Central Office Re-architected as a Datacenter (CORD) re-architects the Central Office as a data center bringing in the already established data center economics and cloud agility. Major Service providers like AT&T, SK Telecom, Verizon, China Unicom and NTT Communications have implemented CORD.

CORD integrates software-defined networking (SDN), network functions virtualization (NFV) and elastic cloud services. With CORD the operator manages their Central Offices using declarative modeling languages. CORD architecture is built from commodity hardware and open source software components. Changing Central Office into CORD consists of two parts:

1. Virtualize hardware devices, thereby producing their software counterpart on commodity hardware.
2. Provide a framework that the software counterparts can plug into in order to forge a unified end-to-end system.

Tejas Management and Control Architecture

Tejas offers multiple options for evolving to an intelligent, software defined network. It is important to evolve the existing networks to SDN rather than discarding existing investments and building a green-field networks which many other network paradigms propose. Tejas provides an evolution path for adding intelligence and automation to existing networks through its hybrid domain controller. Further, it supports open source SDN controllers like ONOS to provide centralized management and control.

SDN Support on Tejas Network Elements

Tejas devices support a REST API through which all key aspects of its functionality can be configured through an industry standard HTTPS interface. The detailed specification of the REST interface is available from Tejas.

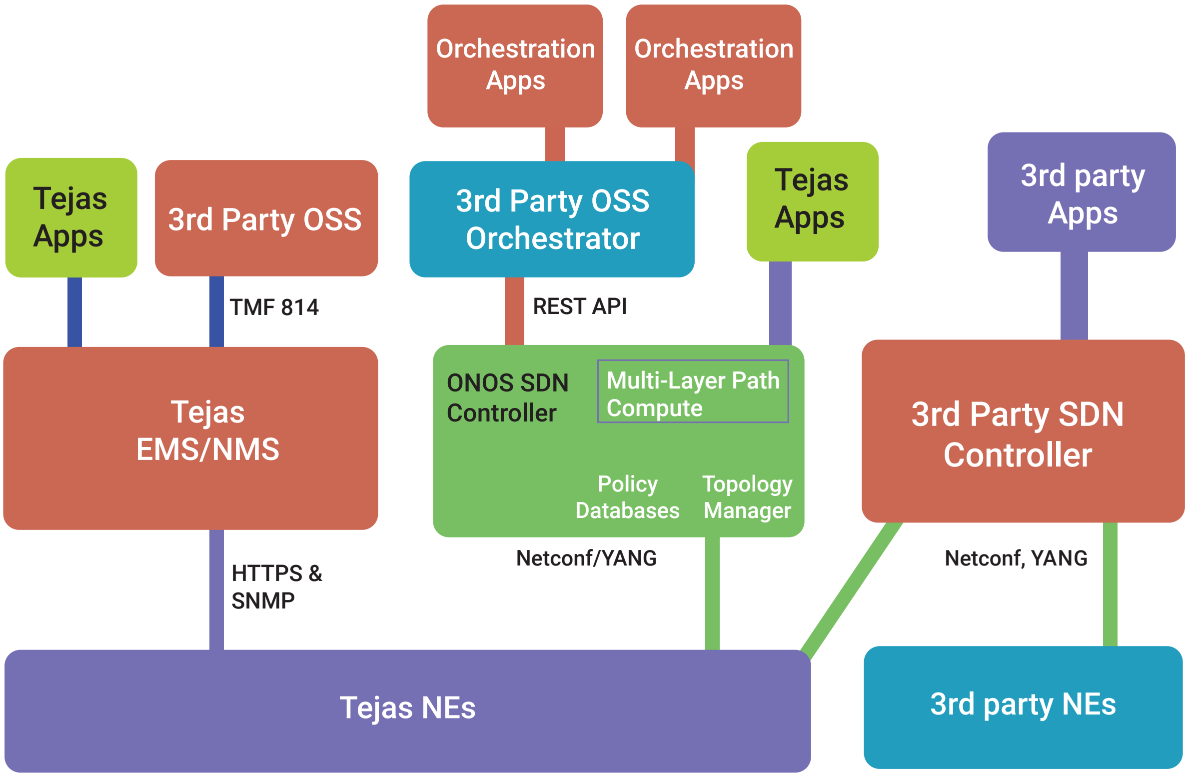

Figure 2: Network architecture and evolution

In addition, future SDN controllers require sophisticated capabilities like support for transactions and rollbacks, fail-safe startups and ability to define and execute complex operations and remote procedure calls. These are enabled by the Netconf protocol standardized by RFC 6241. Yang models which provide the semantics to the data exchanged through Netconf enable the devices to interact with the controller at higher levels of abstraction, thus reducing the complexity at the controller level. Tejas devices support Netconf/Yang through a software upgrade for TJ1400/TJ1600 devices. Through these, Tejas network elements can be integrated with any 3rd party controller supporting Netconf/Yang on its southbound.

SDN Support on Hybrid SDN Controller

Tejas supports programmability and automation capabilities through the TJ5500 hybrid domain controller. This combines the programmability with integrated FCAPS for a multi-layer network, multi-technology network. This supports full FCAPS from the UI itself for provisioning end-to-end DWDM services, end-to-end OTN, MPLS-TP, SDH

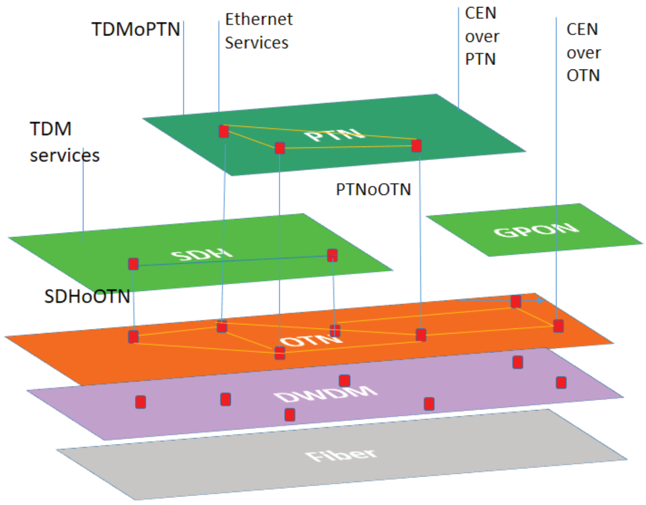

Figure 3: multi-layer and multi-technology network

and GPON. It supports a standard NBI interface for programmability of DWDM, OTN, SDN and GPON services. Many use cases consisting of multi-layer service provisioning scenarios can be automated. Tejas hybrid controller is already integrated with many leading OSSes/Orchestrators in the industry. Tejas also supports VLAN based MEF services and MPLS-TP services through the NBI on the Tejas domain controller.

SDN integration with Open Source Controllers

Tejas is working on integrating it's devices into ONOS (Open Network Operating System) controller through the Netconf/Yang interface. ONOS is a popular open source controller which is architected from ground up for service providers. It addresses key service provider requirements like scalability, high availability and high performance. Besides it is a vendor neutral controller and provides open interfaces both on north bound and south bound. It follows a modular architecture build around microservices, which enables customizations to the functionality by plugging in 3rd party modules/plug-ins into the ONOS platform. There is a large open source community working on the ONOS project.

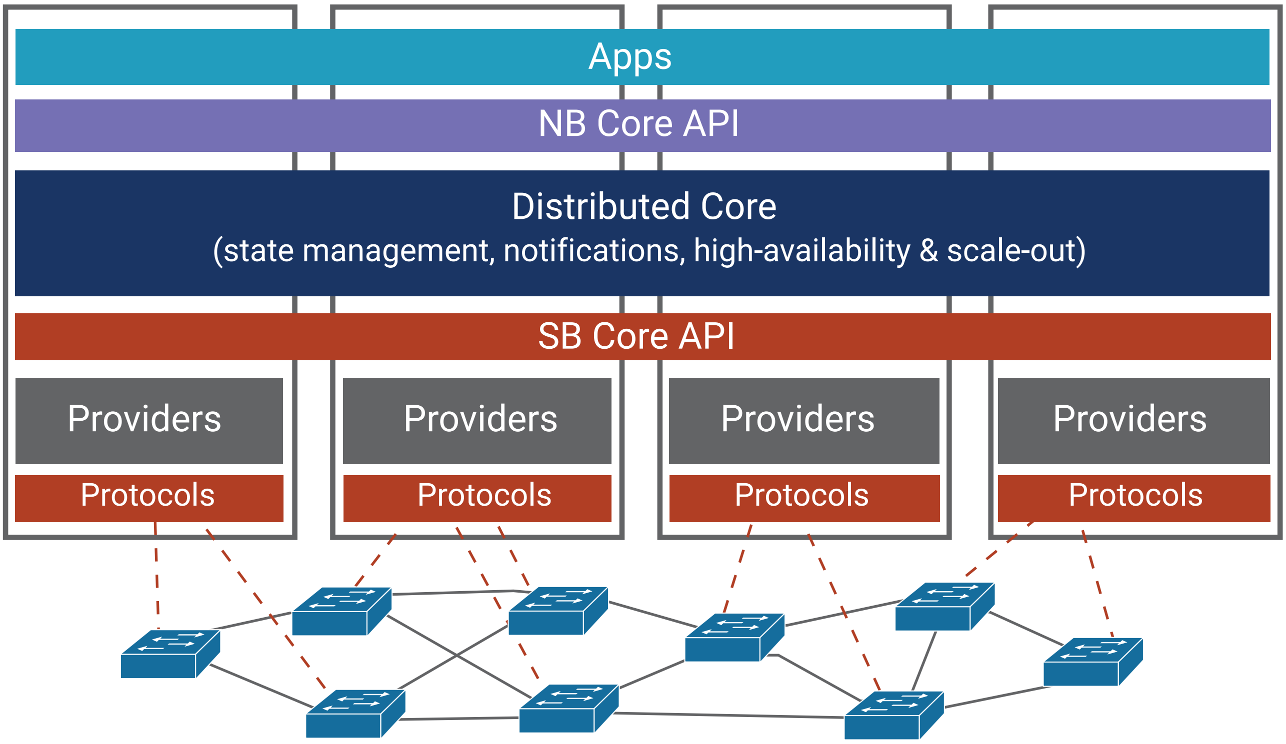

Figure 4: Open Network Operating System

Enabling Automation at the Orchestrator Level

Tejas exposes the APIs and network data to 3rd party orchestrators to support the automation of various workflows through a standards based open interface. Through these interfaces, the orchestrators can get all the relevant data from the network related to network inventory, topology for each individual layer (DWDM, OTN, SDH, GPON, Ethernet), service discovery, outstanding alarms and poll for performance data. The orchestrators can also register with the Tejas controller to listen to notifications for various network events, which enables it to be in real time sync with the network.

Highlights

- SDN-ready network management software
- Open-source domain controllers with standards-based northbound and southbound interfaces
- Virtualized CPEs for OLT/ONT, firewall, IP and common functions
- White-box routers with MEF LSO compliant SD-WAN controllers
- Disaggregated architecture for unlimited scaling
- Support for higher bandwidth 200G/400G interfaces
- Terabit-scale, multilayer switching in small footprint

Advantages for Telecom operators

- Reduced CAPEX spend by pooling of storage and compute functions to low commodity servers and reduced OPEX due to virtualization which automates most manual network configuration tasks
- Ease of management and improved performance by optimizing network device utilization. Use of orchestration helps manage thousands of devices
- Accelerated time to market/revenue with the deployment time reduced to few minutes by setting up a new virtualized service rather than deploy a fixed hardware with the same functionality
- Enhanced security due to implementation of global security policies on the centralized SDN controller
- Telecom operators are spoilt for choice to choose between multi-vendor solutions and modular plugins due to the open frame work.
- Improved resilience and reliability thereby improving the network utilization.

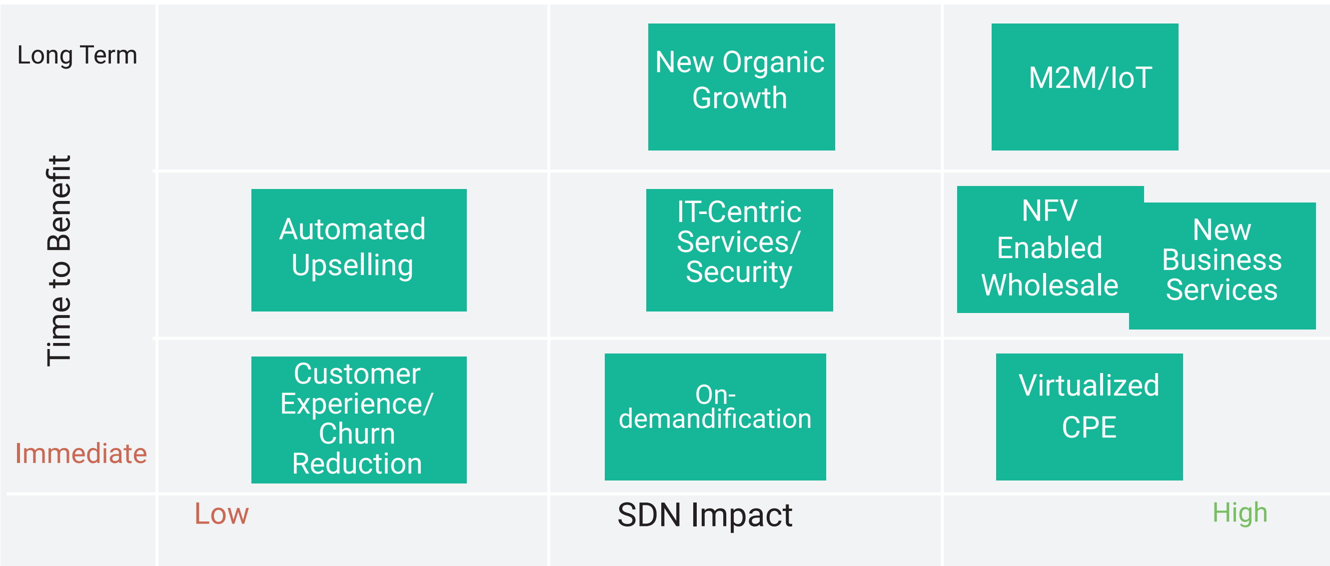

Figure 5: Measuring SDN/NFV Impact

Source: Gartner (September 2017)

Conclusion

SDN is a disruptive technology that will revolutionize the manner in which current networks are built, operated and managed. SDN is a network architecture approach that allows the network to be centrally controlled through software applications. The transport networks are poised to move from a CAPEX intensive and license based model to a multi-vendor, software based, open source support based model. Telecoms need to keep pace with the challenging market demands at lower Average Revenue Per User (ARPU). The requirement for newer services such as usage-based charging models, granular service capabilities and enhanced security is possible.

Tejas actively supports the SDN initiatives of the service providers by offering open, standard interfaces for supporting use cases around programmability, automation and network analytics. Tejas hybrid controllers support full management of a multi- layer network comprising of DWDM, OTN, SDH, GPON and Ethernet technologies. This is complimented by control and automation capabilities of the system. Tejas encourages an evolutionary approach to SDN where brownfield networks are enabled for SDN through software upgrades. These solutions support integrated FCAPS along with SDN control, thus providing the best of both worlds. Tejas is an active participant in India's telecom standards bodies and technical working groups on Optical technologies. We have proven technologies and have supported various custom installations across the world

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