International Journal of Research in IT and Management (IJRIM)
Available online at : http://euroasiapub.org
Vol. 6, Issue 9, September - 2016, pp. 22~35
ISSN(o): 2231-4334 | Impact Factor: 5.96 | Thomson Reuters ID: L-5236-2015

Monetization and Service Management over Software Defined Network

A System Integrator's Perspective

Arup Kumar Roy[1]
Principal Solution Architect
Ericsson India Global Services Pvt. Ltd.

Tarak Nath Mukherjee[2]
Senior Solution Architect
Ericsson India Global Services Pvt. Ltd.

ABSTRACT

To make the promises of SDN technology come true, there is a need for exploring the potential avenues for management and monetization of the services realized over SDN along with the core SDN architecture. Typical SDN, being a concept, when concretized for realization, the focus is more on the south bound integrations between the segregated control and data plane along with cloud based deployment philosophy. However the traditional aspects of Fulfillment, Assurance and Billing (FAB) related business process flows, which are critical to commercial deployment and success of SDN in a Telco environment, are mostly kept untouched in core SDN concept.

This paper focuses on the important aspect of monetization and service management which are complementary to the overall SDN realization drive as far as business processes are concerned.

KEYWORDS :
Software Defined Networks; Management and Monetization of S

INTRODUCTION

Software-Defined Networking (SDN) is transforming WAN designs by decoupling the control and data planes, centralizing network intelligence, and abstracting applications from the underlying network infrastructure using the OpenFlow standard. As a result of this effort, data center and telecom operators will gain unprecedented network automation and control, enabling highly scalable and flexible WAN solutions that readily adapt to changing business needs.

The lack of demand visibility coupled with the lack of a feedback loop between the network and applications forces operators today either to over-provision the network or to be resigned for best-effort service delivery. The emergence of viable SDN solutions is timely to address these challenges that operators face in today's business environment. The following diagram depicts the gradual transition of network view:

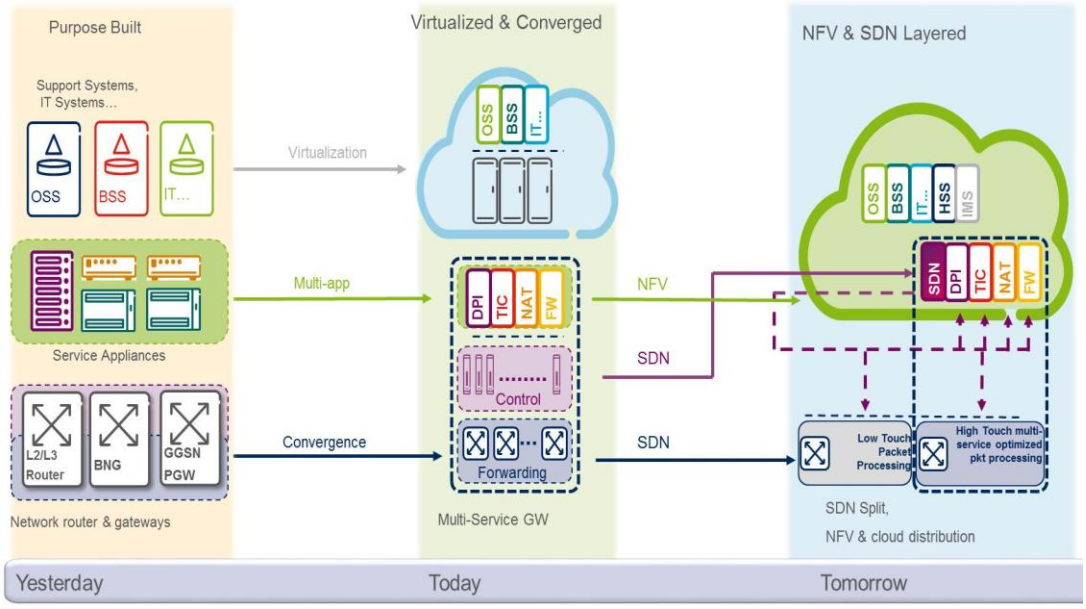

Figure 1: Evolution of SDN Architecture

Deployment of SDN into existing Telco environment would not only drive the need for a network transformation but also bring in a situation where both SDN and legacy network domains need to coexist to ensure that the operators are able to fulfill, assure and bill the services offered over such hybrid networks. In order to cope with such challenges, operator's existing BSS/OSS environment needs well thought evolution in terms of capability to adopt the business processes encompassing both SDN and non-SDN network domains. Undoubtedly, using existing BSS and OSS systems would help the Telco's get more returns on the investments they have already made and avoid the cost of implementing a dedicated support environment for SDN network alone.

SDN AS SERVICE MONETIZATION CATALYST

The SDN framework has the potential to enhance monetization by markedly improving existing services through faster turn-up, more competitive cost, broader coverage & mass customization so that their revenue generation is significantly increased. This section describes role of SDN in catalyzing service monetization in the light of two service varieties Bandwidth on Demand (BWOD) &Virtualized Managed Router Service (VMRS).

Bandwidth on Demand (BWOD)

BWOD offered as Network as a Service (NaaS) over SDN enables enterprise or cloud providers' applications to interact with the network control layer to query network performance and resource availability. This allows the service provider to better coordinate end device capabilities, data center workload placement, and NaaS provisioning to meet their user application bandwidth, class of service, priority, security, and cost-sensitivity needs.

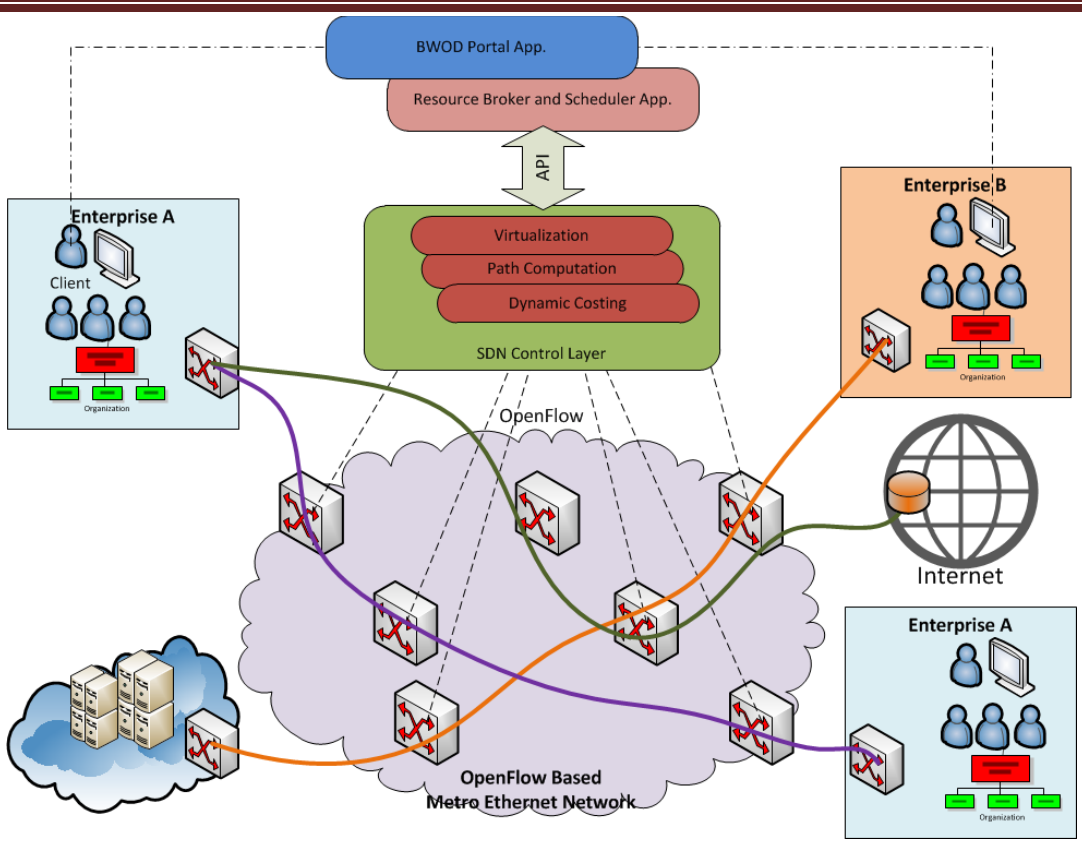

Figure 2: Bandwidth on Demand Service

An analytics engine could evaluate current supply and demand as well as historical temporal demand peaks and supply shortages to raise network cost during shortages and lower them during gluts. Through continual learning of the price elasticity of demand, these adjustments can become more refined, enabling the analytics engine to maximize network revenue per bit transferred.

The following table compares the expected changes in the BWOD offering over SDN as far as customer experience is concerned:

Table 1: BWOD Service over SDN vs. Traditional Data Network

BWOD on Traditional Data Network	BWOD over SDN
a) The lack of automation capabilities makes it difficult to roll out self-provisioned services and respond to time-sensitive changes in bandwidth requirements. b) Customers are given some control and are able to invoke the services through a portal (reducing the need for network operators to be involved in the service order provisioning process) but this is very limited in scope. c) Frequent changes in a distributed control environment sometimes lead to transient overloads caused by the network having to manage traffic from multiple sources that share the same network link, resulting in congestion and instability. d) Lack of a standard interface means operators today must interface their OSS/BSS systems to a vendor-specific network infrastructure. This requires them to either redesign their control applications for each vendor or to limit their services to a single vendor.	a) Deploying BWOD from OpenFlow-based SDN architecture with a programmatic northbound API allows operators to have centralized, granular control over the networking infrastructure. The SDN control layer can leverage topology-aware path computation to cost-effectively enable bandwidth on demand. b) Enables customers to automatically request dynamic changes to bandwidth allocation and other QoS parameters at the packet and/or optical layers, either immediately or scheduled in the future. c) SDN provides a real-time topological view of the network, enables network virtualization, and allows network bandwidth reservation to provide guaranteed performance on a per-connection or flow basis to meet SLA requirements. d) Standardized OpenFlow based provisioning simplifies the southbound integration and break free the vendor dependencies to a large extent.

Hence, in this scenario, SDN enables the operators to reduce both their CAPEX and OPEX by balancing views of both supply and demand and enabling on-demand capacity planning thereby optimizing return on investment.

Virtualized Managed Router Service (VRMS)

Managed router services are a big source of revenue for many operators. They provide customers with clear benefits such as Internet access, firewall protection, and L2 and L3 VPN services without an upfront capital outlay, and without requiring in-house expertise with routers or WAN protocols.

In the traditional managed router approach, the operator installs a small router on the customer premises. Typical customer premises installations also include a Layer 2 demarcation device (NID) to terminate and manage the metro Ethernet access connection to the central office. The CPE router

performs control-plane functions such as route discovery and network address translation as well as data plane forwarding. The connection back in the central office terminates on an Ethernet port on an aggregation router.

A better approach is to deploy only a simpler OpenFlow-enabled NID at the customer site, obviating the need to install and manage a separate router as shown in the figure below. Similarly, in the central office the expensive aggregation router can be replaced by a more cost-effective Layer 2+ OpenFlow-enabled switch. Both are controlled by SDN Controller running in the central office or data center as shown in figure below:

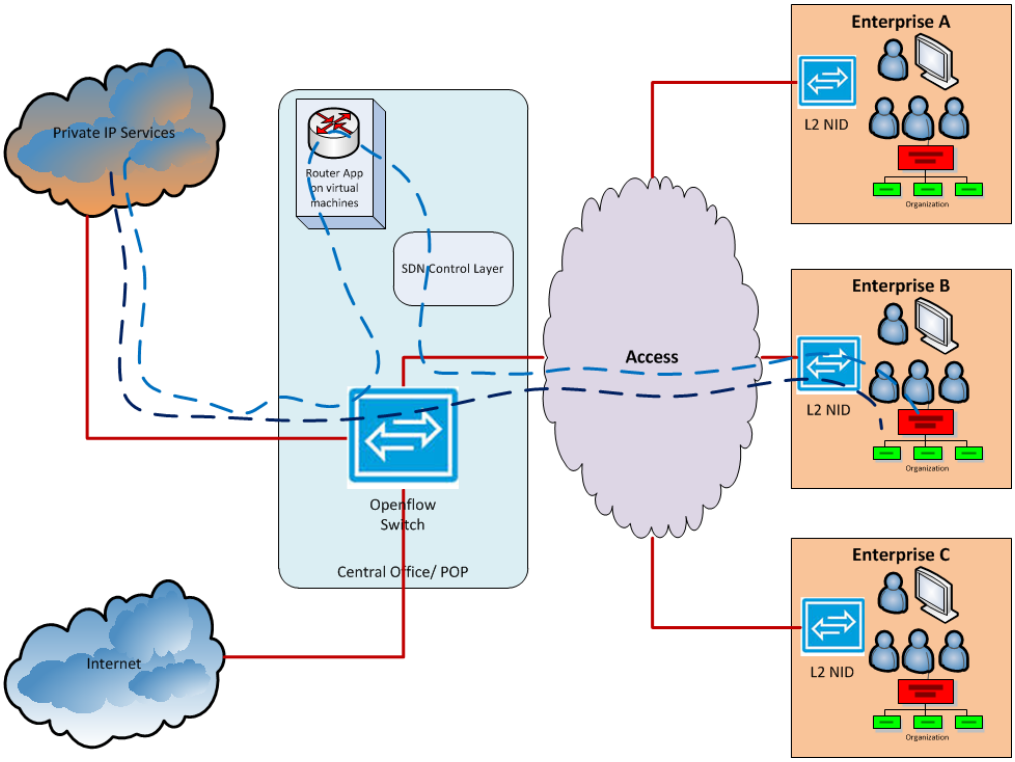

Figure 3: Virtualized Managed Router Service over SDN

Rather than running an embedded, vendor-specific L3 control plane extended out to the customer premises, the complex routing functions are centralized and instantiated as an SDN application on a virtual machine. New L3 flows are automatically directed to the SDN control layer and to the virtual router application that manages route discovery, network address translation, and other features of the managed router service.

In this example, SDN makes the VRMS service delivery and management operations much more scalable and controllable. Since revenue-generating feature enhancements can be installed centrally, they become easily available to any customer served by the service provider.

Let us compare the pros and cons of this service while offered over traditional data network vs. SDN:

VMRS on Traditional Data Network	VMRS over SDN
a) On-premises router deployment and manual provisioning adds complexity to the service delivery process b) Complex configuration, management, and upgrades of the customer-located router increases the burden of service management c) The service provider needs to bear the operational burden of supporting different router versions to cost-effectively support the specific subset of service features for each customer, or else always deploying the same router even when a more basic version would suffice for some customers d) Traditional deployment mechanism eats up expensive port on central office aggregation router e) The service provider needs to continuously change the router as technology churns or customer's needs change	a) Eliminates the management burden and expense of the customer located routers. b) Reduces technology obsolescence at the customer premises. c) Eliminates the need for a CO router, dramatically reducing the cost of aggregation. d) Supports a pay-as-you grow CAPEX model, requiring a modest upfront investment in virtual machines to support router functions that scale with service success. e) Facilitates simplified integration into automated provisioning systems. f) Enables a simple service upsell to "managed firewall" and "managed security" services on demand and without truck roll.

SUCCESS ENABLERS – CHANGE IN VIEW OF TRADITIONAL BSS & OSS

As we saw in the previous section, SDN along with OpenFlow provides numerous benefits that can catalyze network monetization from the perspective of the service providers.

- The ability to view and control allocation of network resources globally makes it easier to dynamically broker network services.
- An open northbound API enables customers and applications to automatically invoke network services that match their needs, making it more fluid and adaptable to customer requirements.
- Global views of both supply and demand enable analytics-based dynamic pricing. Such pricing can maximize revenues and profitability by increasing demand when resources are idle and increasing revenue per bit when resources are scarce.

- A modular, open control framework enables operators to develop their own differentiated network services and network-aware applications.

However, the OpenFlow specification only describes how to manipulate the flow tables of the network switches, but it does not define what the controller should base its "smart" decision on. It's pretty clear that there is a need for guidelines regarding the way in which SDN should be designed, since the controller's "smartness" depends on its ability to obtain a holistic view of the network, services and defined policies. Let us try to analyze the paradigm shift required in traditional BSS/OSS functions in the light of the FAB view of TMFs Business Process Framework (eTOM).

Parties and Their Roles in SDN Business Context

The following table takes a look at the involvement of various Parties along with their possible roles in a generic service delivery context over SDN. It is imperative to say that presence of all the parties is not mandatory in every possible business models.

Table 2: PARTIES & THEIR ROLES

Party	Role
SDN Provider	SDN Provider owns the backbone network running on SDN and sells capacity as NAS to a SDN Partner/ SDN Reseller.
SDN Partner	SDN Partner procures certain capacity from the SDN Provider and has established B2B contract with the SDN Provider. SDN Partner uses the procured capacity for its own business needs (e.g. XYZ Corporation might want to establish corporate WAN over multiple cities using the Metro Ethernet service running on SDN.)
SDN Reseller	SDN Reseller also procures certain capacity from the SDN Provider and uses the same to offer their own overlay services towards End Customers. Example of such parties is VNO, who can use the procured SDN as their backhaul network to offer various access services to the end customers.
End Customer	Consumers who procure end customer facing services from either a SDN Reseller or directly from a SDN Provider (e.g. in case of limited B2C scenarios)

Reference Architecture

The following figure depicts reference architecture of what can be described as the "futuristic" view of BSS/OSS functions in a hybrid network environment comprising of both SDN and non SDN network domains:

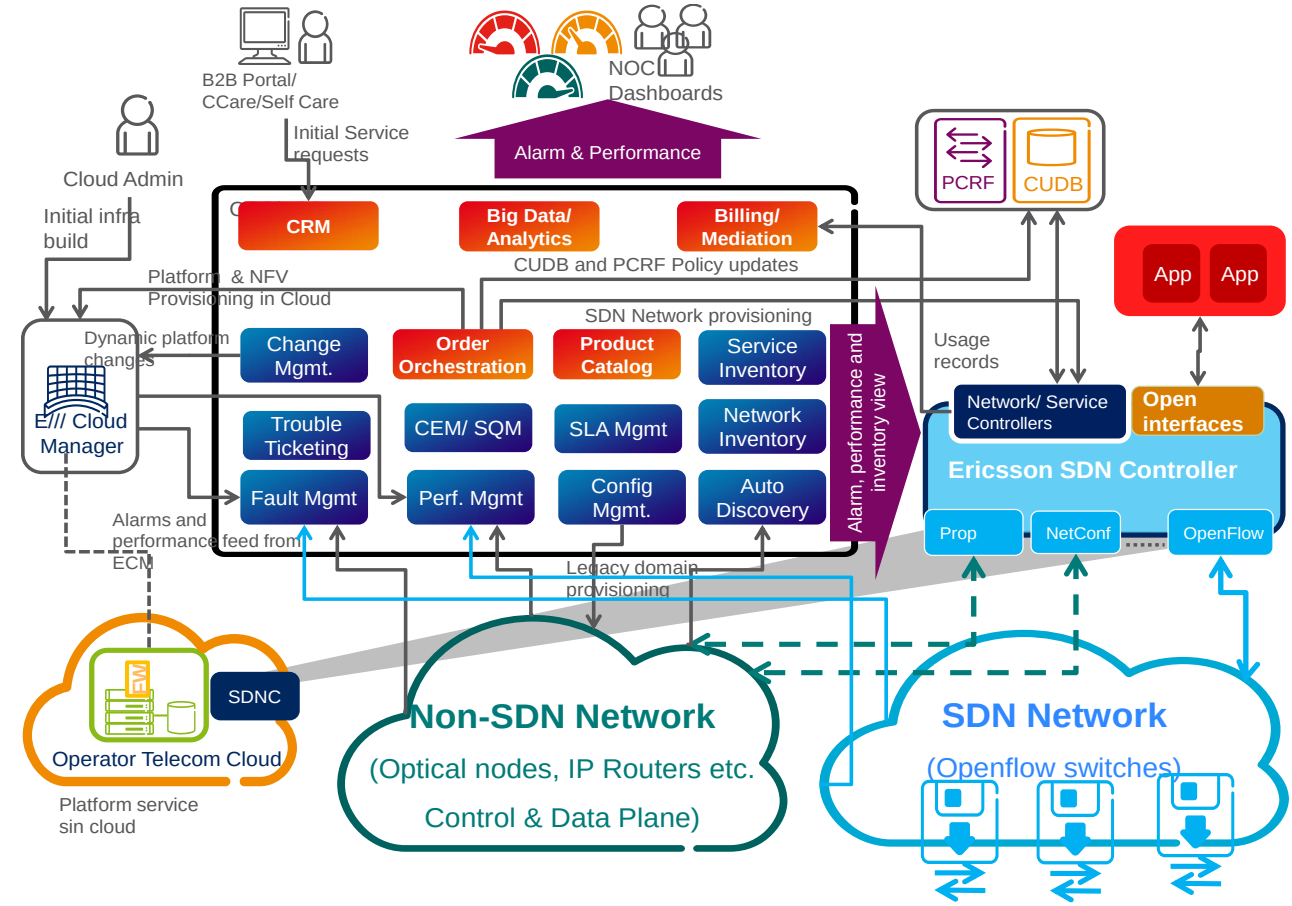

Figure 4: Reference Architecture

Key architectural requirements that come out from the reference architecture are listed below. These requirements are justified further with the help of representative use case scenarios described in page 33.

- The BSS layer of reference architecture is expected to provide a B2B Portal/ Self Care/ Customer Care functionality through which, either the SDN Partners or SDN Resellers will be able to place their requirements for initial/ add-on/revised capacity in form of B2B orders.

- For E2E fulfilment of B2B orders, the Order Management layer should be capable of orchestrating between the Cloud Manager for required infrastructure provisioning, legacy domain managers for non-SDN network provisioning and SDN Controller for SDN network provisioning.

- An Analytics Engine can be used to evaluate current supply and demand as well as historical temporal demand peaks and supply shortages by getting continuous feeds from functions like performance management and route analytics. Through continual learning of the price elasticity of demand, it is expected to help maximizing network revenue over time.

- At this point of time, it is visualized to have postpaid billing and interconnect billing capabilities to be part of SDN Provider's BSS stack. SDN being more of a backbone network and most likely to be offered to either SDN Partners or SDN Resellers to ride their own services, scenarios like hard denial of traffic over SDN by performing real-time balance management might be disruptive. Moreover, if real-time balance management is required for such consumer centric services riding over SDN as a transport, the same can be done without much difference irrespective of SDN is used or not.

- In order to provide the SDN controller with a holistic view of the network, SDN Provider can use the OSS functions that they already have in place with required modifications. As an example, SDN Provider's Network Inventory Management System can be easily justified to provide a complete physical, logical and topology view of a multi-technology, multi-domain network, as it helps the SDN Provider to get more return on the investments they have already made and avoid the costs of implementing a dedicated inventory-like system for SDN technology.

- Traditional OSS assurance functions like Fault Management, Performance Management, Trouble Ticketing and SQM/CEM functions would still be required to provide the NOC like functionality for monitoring the hybrid network domains.

- SLA Management function is expected to gain more complexity in SDN centric environment in order to manage back to back SLAs between SDN Provider, SDN Partners/ SDN Resellers and the Cloud Provider.

More detailed view of each of the fulfillment; assurance and billing related functionalities are described in subsequent sections.

Fulfilment View

Ability to Configure or Reconfigure Services on-the-fly

One of the major dynamic shifts in service fulfillment space that deployment of SDN is expected to bring in is the ability to configure/reconfigure network traffic flow allowing the operators to dynamically respond to the needs of the business. The centralized "SDN Controller" would enable multiple network and security services to connect in series across devices within the network using "SDN Service Chaining".

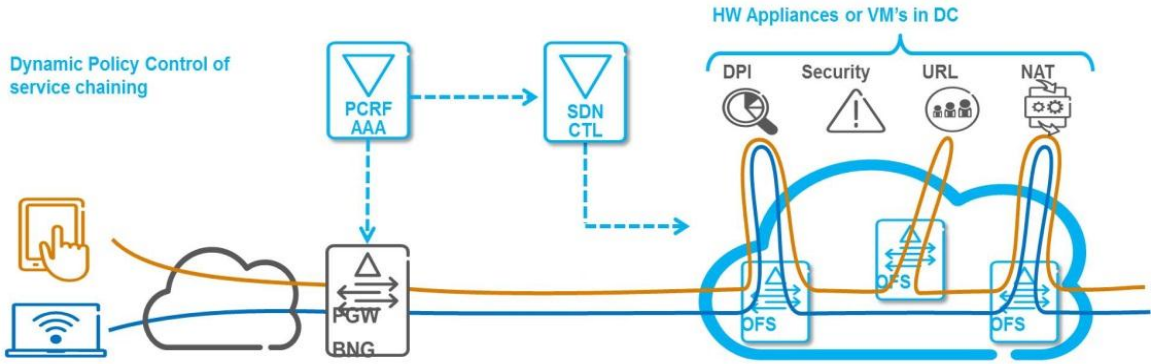

Figure 5: On-the-fly fulfillment via Service Chaining

The diagram above depicts service chaining where there are two distinct data flow paths – one via URL filtering in firewall and the other bypassing the firewall. Once we change Policy on PCRF, SDN controller will automatically update the flow path to effect the dynamic decision on service chaining.

The fulfillment system geared up to cater to the SDN needs is expected to invoke suitable provisioning functions to configure or reconfigure the PCRF policies based on negotiated contract between the SDN Provider and SDN Partners/ Resellers or based on the feedback of the network health fed from assurance systems.

From traditional "push" mode to next generation "pull" mode fulfillment

From service fulfillment perspective, traditional BSS/OSS infrastructure controls the network in a "push" model. It means that during the process of new service fulfillment and delivery, the OSS ecosystem needs to design the E2E services by reserving relevant network resources and apply appropriate configuration into the network elements. In this model the relationship between the OSS system and the network can be described as static. It assumes that once the network is configured, it works independently until a change order is raised for modification of the configured service.

The SDN architecture can transform this static relationship into a more dynamic "pull" model. This means that a controller may access information available in the BSS/OSS infrastructure at runtime, by pulling the data needed to make "smart" decisions.

In the "push" model, OSS needs to know what data should be configured into the network elements. In the "pull" model, the OSS system does not need prior knowledge on all the details of controller algorithms. It is the controller software that is supposed to know, what it needs to be configured in order to provide the best service. This means that in the "pull model" a controller needs to "plug" into the BSS/OSS system to gather the required supportive data. Also the service and resource domain applications on the OSS side (the traditional service and resource inventory systems) should have real-time network view for feeding to the SDN controller to make smart decisions.

There should be close integration between SDN controller and the OSS service and resource

inventory systems where SDN controller is able to query information on need basis by using the exposed APIs from OSS side. Standardization of this kind of interfaces and data models for exchange of such information is the need of the hour. TMFs Integration Framework initiatives around MTOSI for inventory information exchange can be looked into for defining such standards.

Since SDN Controller would always expect the required topology information in a real-time basis in order to perform dynamic rerouting of services, traditional resource and service level inventory systems are expected to have the latest snapshot of the physical and logical inventory information. This, in turn imposes the auto-discovery and reconciliation process to be real-time event driven rather than a periodic batch process.

Assurance View

Intelligent Network Management

SDN comes with the same need for traditional network management functions like capacity planning, monitoring, troubleshooting, security, and other critical management capabilities. Successful monitoring and management of SDN applications requires latest network models and traffic load profiles as well as the ability to predict the impact of change to network routing topologies and traffic flows. In addition, route analytics can take advantage of the unique application insight found in SDN, with network diagnosis, analysis and reporting that is application-aware. For instance, it can report whether the application's servers are best positioned to serve that application's user base.

All this requires more detailed and sophisticated analysis of what's happening in the network. Vendors and the SDN community at large are mostly ignoring SDN analytics, which are crucial for:

a. Troubleshooting and visualization.

b. Determining the network state at any given time.

c. Inspecting and replaying events learned both from the controller and the network devices.

d. Comparing routing state and paths when a service/application is performing well and when it is not.

e. Monitoring paths for changes in hops, metric, delay, and bandwidth.

Multi-dimensional Service Assurance & SLA Management

From and E2E service assurance perspective, the service performance in a SDN environment will depend on

a. Performance of the cloud infrastructure hosting the NFVs (if any) and the controller functions

b. Performance of the NFVs (if any) and controller software entities and

c. Performance of the SDN data plane and

d. Performance of the legacy network domains in case E2E service is realized through multi-domain networks

This means that legacy domain managers are still going to play important role in feeding the alarms and performance statistics possibly through traditional OSS systems whereas the Cloud Manager would be expected to provide similar statistics for the hosting infrastructure of the Controller and the NFVs.

The SLA Management function is expected to tie-up the commitment bindings between the three parties i.e. The SDN Provider, SDN Partner/ SDN Reseller and SDN Software Provider (including NFVs if applicable) both in a B2B or B2C scenario.

Billing View

Current focus of SDN is primarily B2B centric. Mainly postpaid billing followed by B2B settlement would be the predominant model in B2B scenario. In view of the same, either flat rate or elasticity based billing models can emerge in SDN context. Further Elasticity Based Model is expected to focus on Tiered pricing based on elasticity within the agreed SLA combined with SLA driven discounting. In case of network usage capping, policy based control and charging on OSS/BSS nodes may be a good choice for integration with the SDN controller. This type of integration should be on some kind of standardized API or protocols using standard parameter sets. This aspect of BSS/OSS integration is yet to come up very clearly, but this is a must for rapid growth of SDN.

SAMPLE USECASE SCENARIOS

This section describes some of the representative use cases keeping the reference architecture depicted earlier in mind:

Initial Fulfilment of Services (Service Orchestration from SDN Provider Perspective)

1. Assuming that SDN Partner or SDN Reseller will rent or buy the SDN capacity of the SDN Provider, customer acquisition and requests for SDN services can be handled via B2B Portal exposed by SDN Provider or through the SDN Provider's Customer Service

2. Once customer acquisition is confirmed there might be an one-time initial Infrastructure Build required for SDN Partners or SDN Resellers like identification of Physical resources in Telecom Cloud for establishment of the SDN Controllers and possible NFVs. It can be performed in the either of the following ways.

    a. Through the Cloud Management Administrative interface manually and will be a one-time activity per B2B contract with the SDN Provider. SDN Controller instance might be setup in Cloud at this phase.

b. Once SDN creation orders comes from B2B portal to the Order Orchestration layer ,further dependencies can be identified based on service dependency structure setup in the B2B Product/ Service Catalog

3. As part of SDN Service creation request, further details like what are the NFVs required along with their provisioned capacity can be mentioned by SDN Partners (e.g. VNOs). These details along with static information stored in B2B Product Catalog can be used by the Order Orchestration Layer to

   a. Provision infrastructure in Cloud by invoking relevant functions of Cloud Manager

   b. Provisioning the SDN Controller rules along with the policies as per the business plan can be done at this stage in PCRF as well as SQM/SLM or similar functions.

   c. Provision in non-SDN network domains by invoking configuration management/ domain management function of relevant domains

4. As part of the top down order orchestration process the technical orchestration engine will do the required resource reservation, design and assign in the Inventory Management function so that correct inventory view can be fed to the SDN Controller on an ongoing basis to take right decisions.

Dynamic Management of Services

1. Once the initial services are provisioned by the SDN provider and handed over to the B2B Partners in "Service Ready" state, B2B partners like VNOs can work further to hook on their access network to deliver end customer services.

2. With SDN network operational and carrying traffic, OSS functions like FM, PM will monitor the alarms and performance KPIs on a continuous basis. Similarly Cloud Management Function reports the faults and performance KPIs of the various NFVs deployed on cloud to the FM and PM functions

3. The operational status of the network domains along with E2E network and service views (including network over-arching, physical-logical-service layer dependencies) will be made available from Inventory Management systems to the SDN Controller. SDN Controller is expected to use this information along with control layer intelligence for dynamic capacity and routing management of the SDN Domain.

4. In case certain network functions report traffic overload to the PM function or certain NFVs report resource crunch to the FM or PM, the "Change Management" can invoke suitable Cloud Management interface to dynamically allocate resources to the existing NFVs or even dynamically create a NFV and inform SDN Controller about the newly created NFVs so that the overload condition can be balanced out by SDN Controller by updating the flow tables in data plane.

5. The Change Management function might need to know the allocated resource limit (as per elasticity limit set during acquisition), as resource allocation beyond the limit would have billing impact.

6. Overall, SDN Controller as well as OSS along with Cloud Manager forms two "Closed Loop Control" for dynamic capacity management and reconfiguration

E2E Service Assurance

1. The assurance functions in the OSS/BSS eco-system like FM, TT, PM, SQM & CEM can provide e2e assurance dashboards to the NOC/ SOC operators for the services running over SDN & non-SDN network domains and may be using NFVs hosted on the cloud platform (available from Cloud Management System).

2. SQM/SLM can be used to define the SLOs (Service Level Objectives) and based on the SLA limits set per customers and the actual computation of KQIs based on fault and performance data, service SLA violations can be triggered from SQM/SLM. The same violations indications can be absorbed in Billing function for SLA based discounting. PCRF integration with SQM/SLM might be necessary for dynamic SLA check in near real-time.

3. Traditional OSS functionality like Trouble Ticketing and Work Force Management would still be required for raising tickets and allocating the work orders to field forces for any manual intervention required for rectification of any problems in the network or in Cloud platform.

4. Auto-discovery and Reconciliation process will ensure that the physical-logical-service level inventory stored in the Inventory Management System is in sync with the network and represents one single truth.

Billing & Monetization

1. Current focus of SDN is primarily B2B centric. Mainly postpaid billing followed by B2B settlement would be the predominant model in B2B scenario.

2. Following types of billing models can emerge in SDN context:

    a. Flat Rate Model

    b. Elasticity Based Model (Tiered pricing based on elasticity supported with the agreed SLA) with SLA driven discounting

3. SDN Network Service Controllers are expected to generate CDR records along with indication of SLA breaches with date, time, duration etc. These records can be mediated to the postpaid billing function for rating and invoice generation.

4. Interconnect Billing & B2B partner settlement process in SDN Context needs to be in place for amicable revenue settlement between SDN Provider and the SDN Partners.

CONCLUSION

We have seen that deployment of SDN will provide the telecom operators with unprecedented network automation and control, enabling them to provide highly scalable and flexible WAN solutions that readily adapts to changing business needs. However managing the SDN is a new challenging area that needs to be tackled alongside the application-like treatment of the network control functions. Moreover, traditional telecom BSS/OSS functions need to evolve in order to provide the telecom operators necessary confidence in terms of adopting the FAB related business processes encompassing both SDN and non-SDN network domains before they adopt the transformation journey towards complete commercialization their services over SDN.

ABBREVIATIONS AND ACRONYMS

Acronyms	Description
B2B	Business To Business
BYOD	Bandwidth On Demand
CEM	Customer Experience Management
CLE	Customer Premises Equipment
eTOM	Enhanced Telecom Operations Map
DPI	Deep Packet Inspection
FM	Fault management
KPI	Key performance Indicator
NFV	Network Virtual Function
NID	Network Interface Device
PM	Performance management
SDN	Software Defined Networking
SDN	Software Defined Networking
SLM	Service Level Management

REFERENCES

[1] Sakir Sezer, Sandra Scott-Hayward, and Pushpinder Kaur Chouhan, CSIT, Queen's University Belfast "Are We Ready for SDN? Implementation Challenges for Software-Defined Networks", IEEE Communications Magazine - July 2013

[2] ONF, "Software-Defined Networking: The New Norm for Networks," White Paper, https://www.opennetworking.org

[3] COMARCH, "Software Defined Networking – how BSS/OSS tools can help unleash innovation" White Paper, www.tmforum.org/browse.aspx?linkID=54200&docID=21398

[4] Peter Haofei Liu, Huawei Technologies, "The Way towards SDN and NFV: Think Big, Start Small", http://www.huawei.com/ilink/en/download/HW_U_308344

[5] Christopher Price, "Ericsson SDN Controller & OpenDayLight Presentation", 2014 IP & Broadband Technical Summit

[6] Alisa Devlic & Wolfgang John, Ericsson Research; Pontus Skoldstrom, Acreo AB, "A use-case based analysis of network management functions in the ONF SDN model, 2012 European Workshop on Software Defined Networking

[7] ONF Solution Brief, Operator Network Monetization Through OpenFlow™-Enabled SDN, April 3, 2013