

Executive Summary

Service providers' (SP) revenue growth rates have failed to keep pace with their increased traffic growth and related expenses, and the result is a profit squeeze that is forcing SPs to rethink their business models and network designs. Software-Defined Networking (SDN) holds the potential to dramatically reduce total cost of ownership (TCO) while increasing service velocity.

Brocade has developed three SDN use cases built around an SDN controller and Brocade's MLXe series routers that are compliant with the recommendations of the Open Networking Foundation. The services creation and insertion use case automates traffic steering to achieve a desired pipeline of services customized to the needs of each service subscriber. The WAN network virtualization use case provides an OpenFlow overlay to an existing L2/L3 VPN-IP network among data centers to increase service velocity and reduce TCO as compared to the present mode of operations (PMO). The network analytics use case allows the WAN to use OpenFlow to route, filter and replicate to multiple analytics tools. This provides flexible and responsive access to business information needed to increase the efficiency of the networking operation and to support the creation of incremental revenue streams.

ACG Research analyzed the TCO, network capital expense (CapEx), network operation expense (OpEx), and labor cost to process service orders of the three use cases. It found that SDN dramatically increases the speed of bringing order processing systems online and the speed of processing individual service orders. The time to set up the order processing system is reduced from one year under the PMO to four months using SDN. The time to process a single order is reduced by a factor of seven. Though direct costs of building and operating the network are reduced by using SDN the majority of the business benefit of SDN is derived from speeding up and reducing the cost of the service order process.

Key Takeaways

The TCO of three SDN uses cases is analyzed: service creation and insertion, WAN network virtualization and network analytics.

An SDN solution compared to a PMO solution for each use case produced savings of:

- 83% for Service Creation and Insertion
- 61% for WAN Virtualization
- 48% for Network Analytics

Introduction

Software-Defined Networking (SDN) offers service providers a vehicle to reduce service delivery costs and increase service velocity. SDN links networks and applications, enabling direct programmatic control of the network in line with end-users' application needs, rather than programming around the network, as is done today. By having access to network topology information, applications can optimize decisions related to service fulfillment, service placement, and service removal. The network has the intelligence to provide guidance to a key set of applications through abstraction, including peer-to-peer, content distribution, and data center applications.

SDN supports efficient use of network and operational resources in the following ways:

Automation: SDN enables operations automation by linking OpenFlow to Operational Support Systems (OSSs) through software architectures such as REpresentational State Transfer (REST), which enables rapid service changes and service creation.

Efficiency of assets: SDN provides network operators an accurate depiction of network topology and usage and the control to eliminate unnecessary capacity increases and, thus, produces CapEx savings.

Incremental revenue streams: SDN supports self-service portals, enabling customers to tailor the network to accommodate their application or service needs. This increases service innovation, flexibility and responsiveness and drives increased service profitability.

Business intelligence: SDN taps data held in the network to improve many things: from real-time information and location-based offerings to new service insertion points, as well as intelligent applications that can reroute themselves based on network data. The result is better customer quality systems and user experiences, and more efficient network operations.

Three use cases are analyzed to illustrate the business case for SDN:

1. Services Creation and Insertion: SDN automates traffic steering to achieve a desired pipeline of services such as firewall and Intrusion Detection System (IDS).
2. WAN Network Virtualization: Provides an OpenFlow overlay to an existing L2/L3 VPN-IP network among data centers.
3. Network Analytics: An SDN approach to network analytics allows the WAN to use an OpenFlow overlay or passive optical taps for traffic replication to the analytics network, the analytics network to use OpenFlow for traffic filtering and replication to multiple analytics tools, and a network analytics application that resides on the SDN controller.

TCO comparisons are made between the Present Mode of Operations (PMO) and the SDN solution for each use case. A hybrid solution (part PMO and part SDN) also is compared to the PMO for the WAN Network Utilization use case. Four TCO categories are computed for all use case comparisons.

1. CapEx for the WAN router and SDN controller.

2. OpEx items associated with the installation, operation and maintenance of the WAN router and SDN controller.
3. Labor expenses associated with setting up the service delivery systems and software.
4. Labor expenses for processing subscribers' service orders.

In addition, service velocity (the time required to set up service delivery systems and to process individual service orders) is compared for the PMO and SDN solutions.

Role of SDN in Simplifying and Accelerating Service Order Processes

The service order processing workflow involves many operations support systems (OSS), customer facing and network facing activities. Figure 1 provides an overview of the inter-relationships among these elements of the service order processing function.

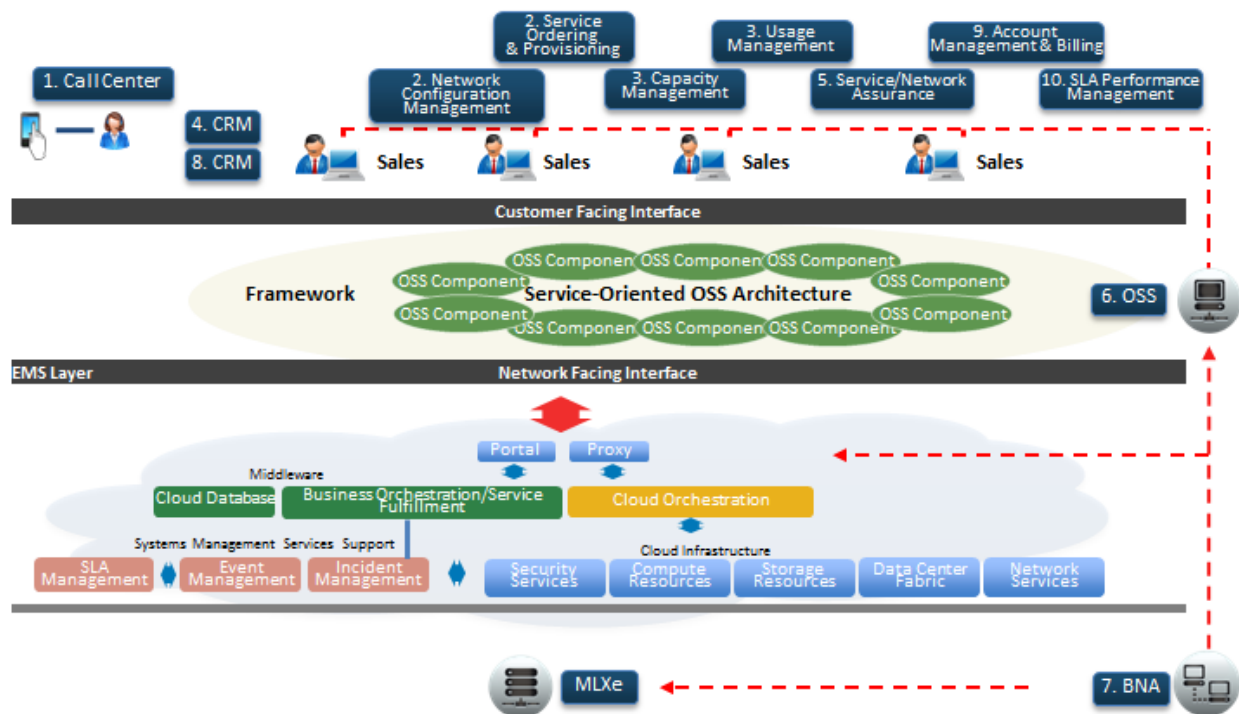


Figure 1 – Overview of Service Order Processing

The service order processing function includes activities such as call center operations, usage management and network configuration management. OSS software components organized as a service-oriented OSS architecture support each of these activities. Customer-facing interfaces are maintained between each customer's activity and its associated OSS component, and network-facing interfaces are maintained between each OSS component and element management systems associated with each network element.

Under the PMO many disparate databases, automated and manual processes provide the linkages among customers and the underlying network elements (network infrastructure). SDN makes the

linkages among customers and network elements explicit and automated. The next paragraphs provide a detailed comparison of PMO versus SDN service order processing.

Figure 2 illustrates PMO workflows.

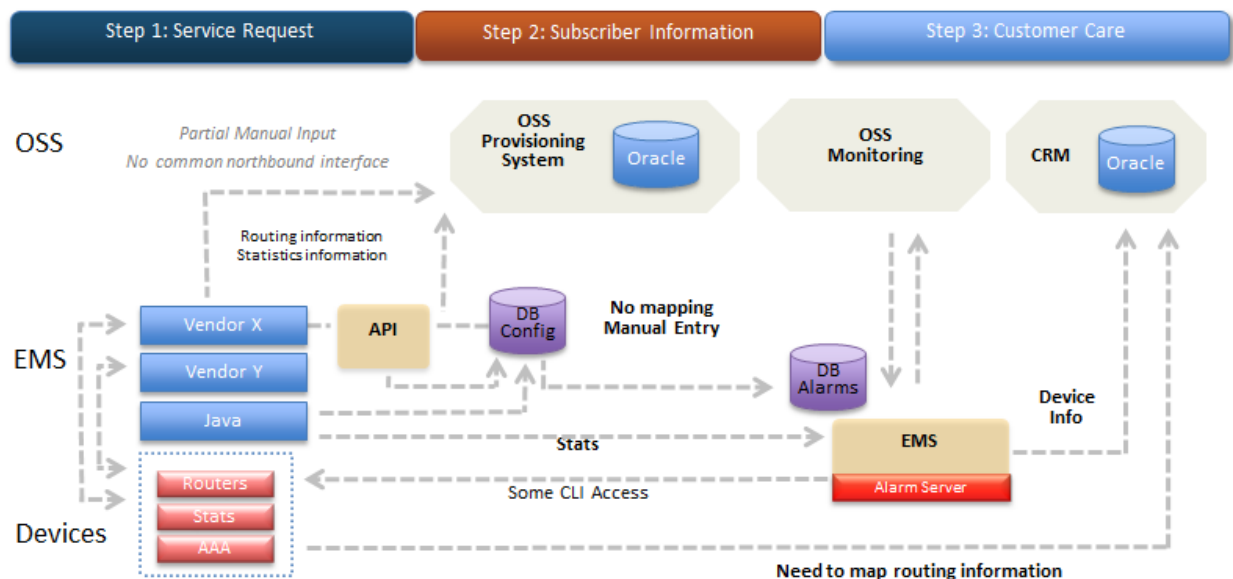


Figure 2 – PMO Service Order Processing Workflows

The work flows from left to right in the figure. EMSs must provide access to each vendor’s network elements so that service orders can be executed. In the second step customer state information must be mapped to individual network elements (devices). Device and routing information must be passed to the CRM system.

Figure 2 shows that the PMO has many inconsistencies and manual processes that retard service velocity and impair the quality of the service order process. There is no common northbound interface between the EMSs and the OSS components. This increases complexity that can obstruct service velocity and introduce errors. Some northbound data is entered manually, which is even slower and more error prone. Each EMS has its own proprietary database and API, which introduces further complexity. Passing of customer state information between the configuration database of each EMS and the OSS provisioning system is particularly slow and error prone because there is no mapping of a customer’s state to network devices. This must be done manually. Finally, passing of network device and routing information from each EMS to the CRM system requires custom programming for the EMS system of each system vendor.

Figure 3 illustrates SDN service order processing workflows.

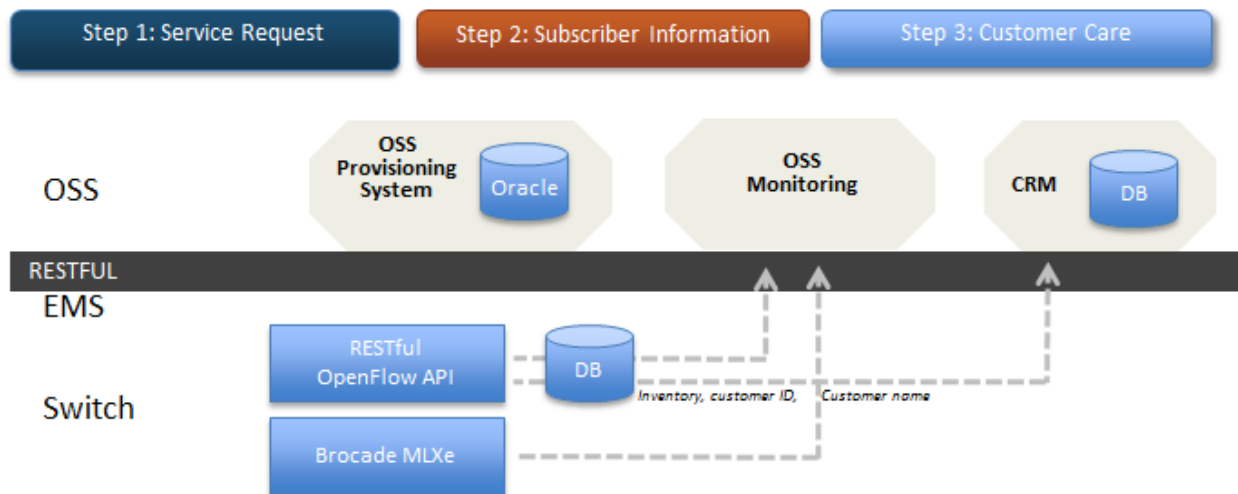


Figure 3 – SDN Service Order Processing

The figure shows a greatly simplified workflow as compared to the PMO. Databases are standardized and consolidated. All APIs are OpenFlow. REST software architecture rather than various vendors' proprietary EMS systems is used throughout, and all manual interfaces have been eliminated. This simplifies service order processing and results in lower setup and processing costs and higher service velocity.

Service Creation and Insertion Use Case

The services creation and insertion use case automates traffic steering to achieve a desired pipeline of services and customizes services to meet each customer's specific needs. Figure 4 illustrates the network configuration.

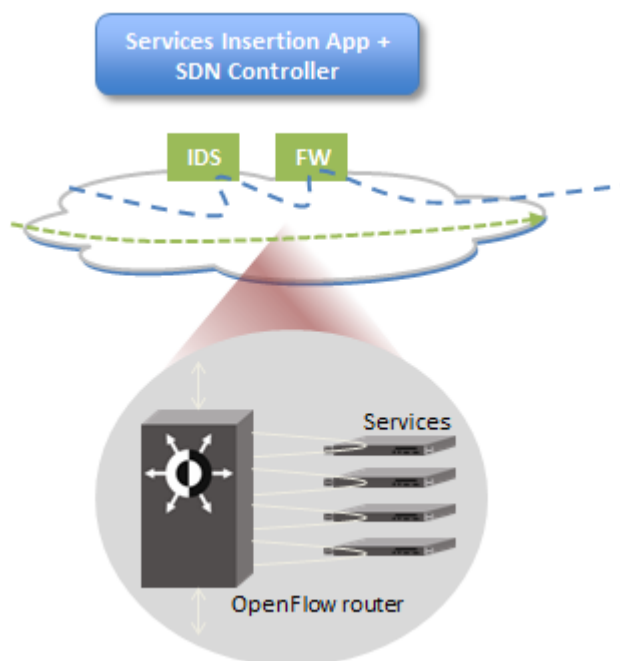


Figure 4 – SDN Service Creation and Insertion

The network consists of an OpenFlow-enabled router that steers traffic to IP services (firewall and IDS in this example). An SDN controller and services insertion software provide routing and configuration commands to the router. Standardized APIs support automation of the service creation process thereby eliminating the use of CLI and other manual service creation processes. Standardization on OpenFlow also eliminates the use of disparate vendor-specific EMSs used to control the individual IP services.

This configuration optimizes the use of network resources by eliminating the need to steer traffic through the IP service appliances. This increases the traffic utilization of the router and on each IP service appliance that, in turn, reduces I/O port requirements and associated CapEx. The sources of CapEx savings are analyzed in the TCO results discussion that follows. Finally, service velocity is increased (as discussed in the previous section), which results in much faster service delivery and significantly lower service order processing costs.

WAN Network Virtualization Use Case

The WAN network virtualization use case is a protected traditional L2/L3 VPN-IP network interconnecting data centers with an OpenFlow overlay. Figure 5 provides an overview of the network architecture.

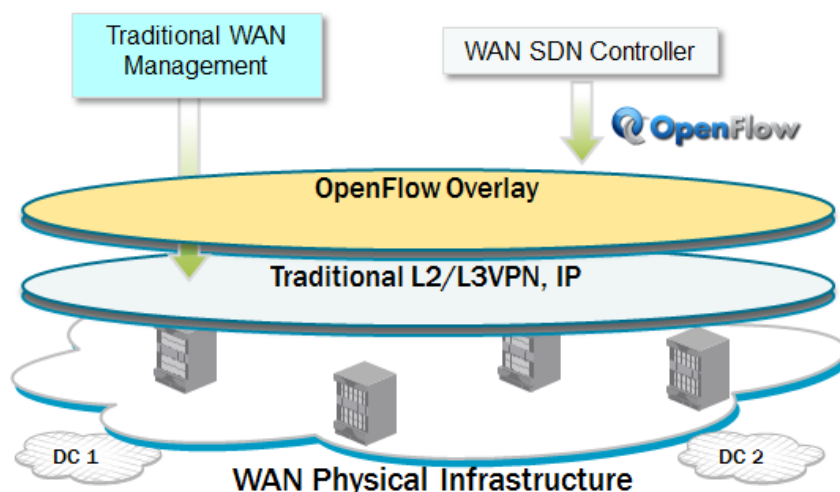


Figure 5 – WAN Network Virtualization

In this design an OpenFlow overlay and associated WAN SDN controller is added to an existing production network. OpenFlow does not affect traditional traffic, and protection is provided in hardware. A hybrid port mode is created. This allows for deployment of the initial OpenFlow overlay service with reduced risk to ongoing operations. As SDN handles an increasing traffic share network capacity additions are reduced because SDN provides better network usage visibility and routing flexibility that allows operation at higher capacity utilization levels.

Centralization of network control in the SDN controller also reduces network CapEx by allowing the use of lower cost line cards in each WAN router. As discussed previously, SDN increases service velocity with very large reductions in service delivery times and service order processing costs.

Network Analytics Use Case

An SDN approach to network analytics allows the WAN to use an OpenFlow overlay or passive optical taps for traffic replication to the analytics network. Figure 6 illustrates a network analytics use case for a mobile operator.

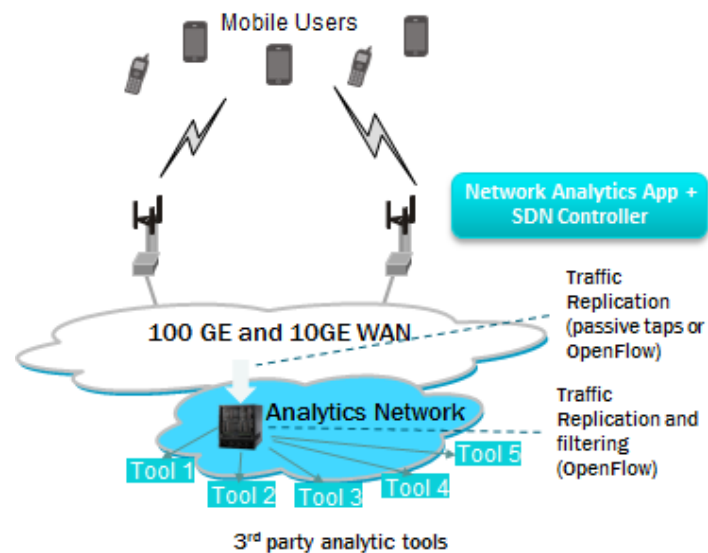


Figure 6 – Network Analytics for a Mobile Operator

Network analytics are used to provide real-time network statistics for collection and alerting, summarization of normal and abnormal traffic, and detection of network performance issues in advance of customers' complaints. Under SDN the WAN may use an OpenFlow overlay or passive optical taps for traffic replication to the analytics network. A centralized network analytics software application and SDN controller use an OpenFlow router to provide traffic filtering and replication to multiple analytic tools.

The OpenFlow router in combination with the network analytics application and SDN controller optimizes the use of network resources by eliminating the need to steer traffic through the network analytics tools and without impacting the production network and users. Centralization of the route processing function in the SDN controller allows lower cost line cards to be deployed in the router, which reduces overall network cost. Finally, service velocity is increased (as discussed previously), which results in much faster service delivery and much lower service order processing costs.

Network Analytics Applications

Data analysis is moving from a batch or data warehouse paradigm to a real-time streaming data model.

Analytics tools include:

- HTTP Analyzer
- VoIP Analyzer
- Intrusion Detection
- Billing Applications

Analytics tools are being applied in many fields:

- Telephony
 - CDR processing
 - Churn prediction
- Stock Market
 - Weather impact on securities prices
 - Ultra-low latency market analysis
- Law Enforcement, Defense, & Cyber Security
 - Real-time multimodal surveillance
 - Situational awareness
- Fraud Prevention
 - Detecting multiparty fraud
 - Real-time fraud prevention
- Health & Life Sciences
 - Epidemic early warning system
 - Remote healthcare monitoring
- Smart Grid & Energy
 - Demand-side management
 - Distribution automation

TCO Analysis

The TCO for the three use cases is compared for the SDN solutions versus the PMO solutions.

Common TCO Modeling Assumptions

The following modeling assumptions are made for all three use cases:

- CapEx is computed for the PMO or SDN router, SDN controller and the element management system of the PMO.
- Network OpEx includes operations expenses required to deploy and maintain the router, SDN controller and element management system of the PMO.
- Labor costs only are computed for setup of the service order processing system and for processing service orders.
- TCO is computed for five years.
- All CapEx and the labor cost to set up service order processing are incurred in the first year.
- Network OpEx and the labor cost of service order processing are computed for five years.
- Brocade MLXe series routers are used for the PMO, hybrid, and SDN use case solutions; MLXe line cards with higher processing capacity are deployed for the PMO.

Service Creation and Insertion Use Case TCO

The TCO of the PMO and SDN solutions is compared for the service creation and insertion use case by modeling the single router chassis solution in Figure 4. Input data and assumptions are shown in Table 1.

Input Item	Amount
WAN 10GE Ports	14
PMO Maximum Port Utilization	50%
SDN Maximum Port Utilization	80%
Number of Service Orders Processed per Day	100

Table 1 – Input Items for Service Creation and Insertion Use Case

Port utilization is higher for the SDN solution than for the PMO due to the network awareness of the business applications and the business intelligence provided by the SDN network design¹.

Service Creation and Insertion Use Case TCO Comparisons

Table 2 summarizes the TCO analysis.

TCO Category	(\$ Millions)		Percentage Savings
	PMO	SDN	
Network CapEx	\$1.0	\$0.6	-39%
Network OpEx	\$1.1	\$0.8	-31%
Labor Cost for Order Processing Setup	\$0.3	\$0.1	-77%
Labor Cost for Order Processing	\$43.7	\$6.2	-86%
TCO	\$46.1	\$7.7	-83%

Table 2 – TCO Comparison for Service Creation and Insertion

¹ See the “Service Creation and Insertion Use Case” section of the whitepaper for further discussion of SDN enabled network awareness and business intelligence.

Although SDN produces substantial percentage savings in all cost categories, labor cost savings of order processing are significantly larger than those of the other categories. (The role of SDN in increasing service velocity and reducing order processing costs was discussed in a previous section.) Order processing time is reduced from seven hours under the PMO to one hour using SDN. The time to set up the order processing system is reduced from one year under the PMO to four months using SDN. Labor cost savings are reduced in the same proportions.

Network CapEx is 39 percent lower for SDN than PMO. The savings come from three sources:

1. Higher utilization of network resources: SDN links the applications layer in real time to the physical network; in-turn, the network provides real-time state information to the applications layer. The two-way information flow permits compliance with SLAs at higher port utilization levels and thus reduces CapEx requirements.
2. Better scale effects from 100 Gbps router ports: Brocade MLXe 100 Gbps router ports have lower unit costs (\$/Gbps) than lower speed ports. The more intelligent approach of SDN to network control leverages the 100 Gbps port scale economies.
3. Low-cost 10 GE line cards: The centralized SDN control plane reduces the need to provide route processing functions on the individual line cards. The cost savings achieved by using low-cost line cards more than offsets the cost of the centralized SDN controller and produces a net CapEx reduction.

Figure 7 breaks out the individual network OpEx cost categories and labor cost associated with setting up the order processing system.

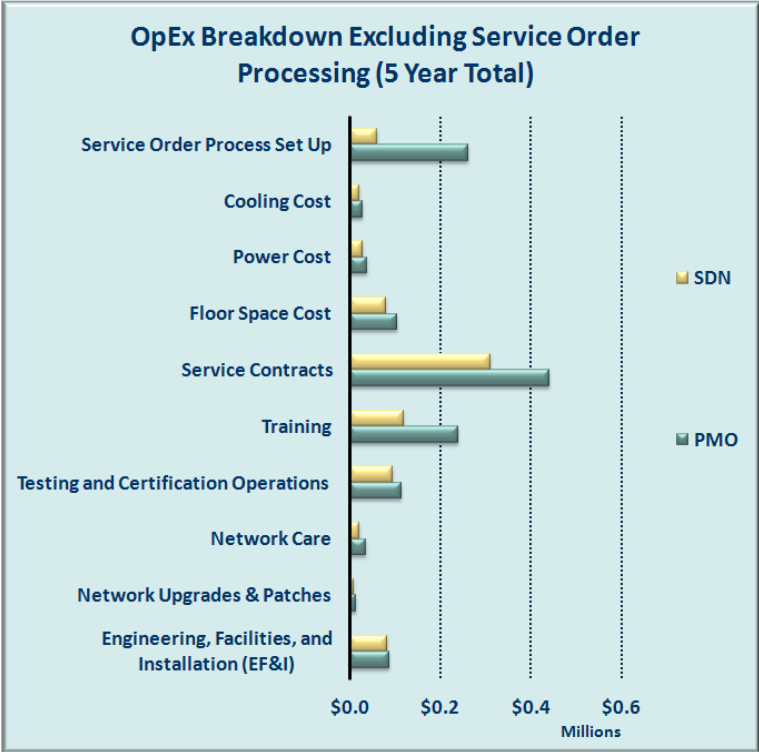


Figure 7 – OpEx Breakdown Excluding Service Order Processing for Service Creation and Insertion Use Case

The largest OpEx savings are realized in the service order process setup, training and service contract expense categories. Service order process setup costs less under SDN because consolidation and standardization of databases and use of a standard API (OpenFlow) and Restful APIs take much of the work out of the setup process. Training costs are reduced because using a centralized SDN controller limits the number of people who must receive intensive training on the control plane functions. Service contract expense is closely linked to CapEx. The lower CapEx of the SDN yields correspondingly lower service contract expense.

WAN Network Utilization Use Case TCO

The TCO for the WAN network utilization use case is compared for PMO, SDN and a hybrid solution where traffic is gradually moved from PMO ports to SDN ports. The architectural design is shown in Figure 5. The WAN interconnects eight data centers using the network topology shown in Figure 8.

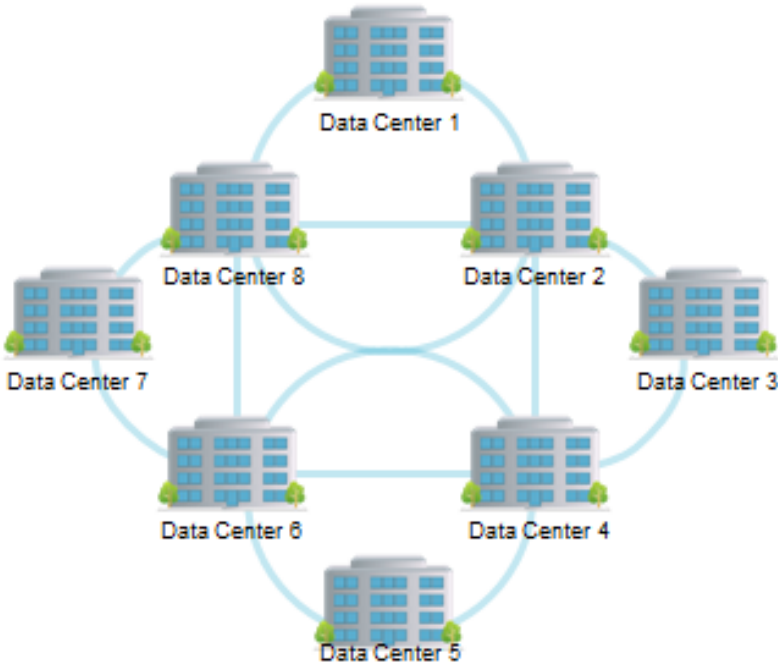


Figure 8 – Inter-Data Center WAN Network Topology

An Open Shortest Path First routing algorithm is used to assign port requirements on the WAN, giving data center side ports as input data for each data center. Input data and assumptions are in Table 3.

Input Item	Amount
Number of WAN Nodes	8
Capacity Expansion Model	Greenfield
Backup Protocol	1+1 Fast Reroute
Core Router Port Size	10GE
PMO Maximum Port Utilization	50%
Hybrid Maximum Port Utilization	65%
SDN Maximum Port Utilization	75%
Number of Orders Processed per Day	10

Table 3 – WAN Network Virtualization Inputs and Assumptions

Table 4 displays the number and size of ports on the data center side of each WAN node.

Node Number	Number of Ports	Port Speed
1	8	10GE
2	14	10GE
3	2	100GE
4	1	100GE
5	2	10GE
6	3	10GE
7	3	10GE
8	2	10GE

Table 4 – Ingress Ports at Each WAN Node

WAN Network Virtualization Use Case TCO Results

Table 5 summarizes the TCO comparison.

TCO Category	TCO (\$ Millions)			Percentage Savings	
	PMO	Hybrid	SDN	Hybrid	SDN
Network CapEx	\$3.3	\$2.1	\$1.7	-37%	-49%
Network OpEx	\$2.9	\$2.7	\$1.8	-10%	-38%
Labor Cost for Order Processing Setup	\$0.3	\$0.1	\$0.1	-77%	-77%
Labor Cost for Order Processing	\$4.4	\$2.5	\$0.6	-43%	-86%
TCO	\$10.9	\$7.3	\$4.2	-33%	-61%

Table 5 – WAN Network Virtualization Use Case TCO Comparison

The SDN and hybrid solutions have 61 percent and 33 percent lower TCO, respectively, over five years as compared to the PMO solution. In this use case labor cost for order processing does not overwhelm the other TCO cost categories as it did in the service creation and insertion use case. The WAN network virtualization use case uses significantly more network equipment and has a much lower order processing requirement as compared to the service creation and insertion use case.

SDN produces substantial network CapEx savings due to the centralization of the control plane function and the increase in two-way information flows between the applications layer and the physical network. This and the dramatic reduction in service order processing costs of the SDN are the root causes of TCO savings of the SDN and the hybrid solutions.

Network Analytics Use Case TCO

The TCO of the PMO and SDN solutions is compared for the network analytics use case by modeling the single router chassis solution shown in Figure 6. Input data and assumptions are displayed in Table 6.

Input Item	Amount
WAN 10GE Ports	8
PMO Maximum Port Utilization	50%
SDN Maximum Port Utilization	80%
Number of Service Orders Processed per Day	5

Table 6 – Input Items for Network Analytics Use Case

Port utilization is higher for the SDN solution than for the PMO due to the network awareness of the business applications and the business intelligence provided by the SDN network design².

Network Analytics Use Case TCO Comparisons

Table 7 summarizes the TCO analysis.

TCO Category	(\$ Millions)		Percentage Savings
	PMO	SDN	
Network CapEx	\$0.6	\$0.5	-13%
Network OpEx	\$0.7	\$0.6	-17%
Labor Cost for Order Processing Setup	\$0.3	\$0.1	-77%
Labor Cost for Order Processing	\$0.9	\$0.1	-86%
TCO	\$2.5	\$1.3	-48%

Table 7 – TCO Comparison for Network Analytics

SDN produces significant increases in service velocity (the time to set up the network analytics production process and to execute orders for new analytic services) and corresponding decreases in the labor cost to execute orders for new analytic services. This provides the flexibility and speed needed to achieve operational excellence and support proactive marketing and sales initiatives.

Conclusion

SDN offers a process for reducing service delivery costs and increasing service velocity. SDN design supports process automation and enhances the two-way flow of business intelligence between the network infrastructure and high-level business applications thereby increasing the efficiency of network assets and supporting the creation of incremental revenue streams.

The TCO of three use cases are analyzed:

1. Services Creation and Insertion: SDN automates traffic steering to achieve a desired pipeline of services such as firewall and IDS.
2. WAN Network Virtualization: Provides an OpenFlow overlay to an existing L2/L3 VPN-IP network among data centers.

² See the “Network Analytics Use Case” section of the whitepaper for further discussion of SDN enabled network awareness and business intelligence.

3. Network Analytics: An SDN approach to network analytics allows the WAN to use an OpenFlow overlay or passive optical taps for traffic replication to the analytics network, analytics network to use OpenFlow for traffic filtering and replication to multiple analytics tools, and a network analytics application to set on top of the SDN controller.

Table 8 summarizes the percentage savings produced by SDN as compared to PMO for the three use cases.

TCO Category	SDN Percentage Savings Compared to PMO		
	Service Creation & Insertion	WAN Virtualization	Network Analytics
Network CapEx	39%	49%	13%
Network OpEx	31%	38%	17%
Labor Cost for Order Processing Setup	77%	77%	77%
Labor Cost for Order Processing	86%	86%	86%
TCO	83%	61%	48%

Table 8 – SDN Percentage Savings of TCO as Compared to TCO

Service velocity is also dramatically increased by reducing order processing setup time from one year to four months and by a seven to one reduction in order processing time.

ACG Research

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