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Seamless Data Center Interconnect

Delivering unrestricted data center networking across the WAN

Application Note

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Abstract

The value of cloud services lies in the rapid and cost-effective instantiation of applications that can be consumed by users anywhere. Today, software defined networking (SDN) technology is being implemented in next-generation data centers to build networks that can be configured as quickly as the underlying compute and storage resources. To unleash the full value of cloud services, the network inside the data center must operate seamlessly with the network interconnecting data centers and end users.

Nokia is at the forefront of delivering breakthrough Cloud Interconnect solutions. For service providers and enterprises looking to leverage existing WAN technologies — Carrier Ethernet and IP VPN — to extend network connectivity between data centers, as well as between data centers and end users, this application note presents the Nokia 7750 SR Seamless Data Center Interconnect solution. Delivering unrestricted data center networking across the WAN, this solution features the 7750 Service Router (SR) as a data center gateway with seamless integration with the Nuage Networks Virtualized Services Platform (VSP).

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Introduction

Data centers are an integral component in the transition to cloud-based service delivery models. The increasing importance of data centers for cloud services and, moving forward, advanced networking functions, such as Network Functions Virtualization (NFV) will result in a significant proliferation of data centers within service provider and enterprise networks.

The cloud services market is poised to expand at a significant rate. Frost and Sullivan estimate that the global cloud computing market will increase from $36 billion in 2013 to $86 billion in 2016.[1] As a result of this growth, a major shift in wide area and data center networking is underway. Indeed, a recent Nokia Bell Labs study projects data center interconnect and user-to-data center traffic to increase more than 440 percent by 2017[2].

Data centers, where powerful compute and storage resources reside, have been experiencing significant changes during the past few years. Server virtualization is the watershed event, which has made compute resources much more dynamically consumable. It has paved the way for dynamic resource sharing in servers, and catalyzed the move to the cloud. This change in compute and storage resources has also triggered a profound impact on the data center network infrastructure. While application turn-up on virtual compute platforms takes only minutes, data center network configuration to support those platforms has been taking weeks or even months to implement.

To address the speed and efficiency constraints of the data center network, a SDN-based solution is being used to virtualize the data center network and automate network service delivery. Leveraging SDN technology, service providers and enterprises can now build a robust and scalable multi-tenant data center networking infrastructure. This infrastructure delivers secure virtual slices of readily consumable compute, storage and networking resources instantaneously across thousands of applications and user groups. Having virtualized the data center network, next-generation cloud services require this connectivity to be seamlessly extended across the WAN to remote data centers and end users.

This application note describes the role of the Nokia 7750 SR as a data center gateway, enabling seamless connectivity between an SDN-enabled data center and the IP/MPLS WAN network.

1 Web Host Industry Review, July 14, 2014.

2 Bell Labs Metro Network Traffic Growth: An Architecture Impact study, p. 1.

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Evolution of networking technologies within the data center

Several networking technology options are available within the data center network. Driven by the simplicity and ubiquity of Ethernet technology, Ethernet-based virtual local area networks (VLANs) are by far the most prevalent technology within data centers. However, the scale required to support large data centers and their related networking requirements has exposed the limitations of VLAN technology. VLANs must be manually provisioned in multiple places without network and service auto-discovery. In addition, VLAN scalability is limited by the 4K VLAN ID Media Access Control (MAC) address space and relies on the Spanning Tree Protocol (STP) for resiliency. Moreover, centralized IP routes can lead to tromboning, variable network performance, extra latency and link congestion. Limitations such as these make virtual machine (VM) mobility with scalable auto-move of service connectivity very complex.

Data center network technologies need to evolve to meet current and future data center requirements. The network should not become a bottleneck when rapid on-demand provisioning at scale is required. To meet this challenge, network virtualization overlay (NVO) technology is being adopted for data center networking.

Understood at a high level, an overlay is a tunnel that carries data traffic between two endpoints. Overlays provide a number of benefits, such as virtual private networks (VPNs) for multi-tenancy, network virtualization for location independence of resources within and between data centers, improved resource allocation, flexible service chaining and protection from topology or technology changes.

Virtual Extensible LAN (VXLAN) has emerged as the de facto standard, and addresses data plane needs using overlay networks within virtualized data centers that accommodate multiple tenants. VXLAN encapsulates the Ethernet MAC frame using the User Datagram Protocol (UDP). The header has a 24-bit virtual segment, which provides more than 16 million VXLAN IDs. Each VXLAN frame can be easily transported across an IP network. VXLAN avoids the Layer 2 MAC explosion, because VM MAC addresses are learned only at the edge of the network.

Bridging the data center and WAN worlds has led to the development of Ethernet VPN (EVPN).[3] EVPN inherits over a decade of operational experience in production networks, and incorporates flexibility for service delivery over Layer 3 networks. In EVPN, the control plane and data plane are abstracted and separated. IP/MAC learning is performed in the control plane instead of the data plane. Multiprotocol-Border Gateway Protocol (MG-BGP) is used as the control plane protocol. This brings proven and inherent BGP control plane scalability to MAC routes, and can even be extended with hierarchy and route reflection. EVPN supports several choices for the data plane encapsulation — Multiprotocol Label Switching (MPLS), Provider Backbone Bridge (PBB) and NVO. It provides a 24-bit VPN identifier that brings the required scalability for the transport of tenant Layer 2 and Layer 3 VPN services. Because it uses UDP, EVPN can run over a basic IP network. Moreover, EVPN allows the use of existing underlay IP network resiliency and load balancing mechanisms such as Equal Cost Multi-Path (ECMP) and IP Fast Reroute (IP FRR).[4]

Data center-WAN integration

The goal for cloud-based service delivery is clear: treat data center network resources with tenant subnets extending across the WAN as an elastic resource pool of capacity that can be consumed and repurposed on demand. To ensure unrestricted networking across the WAN, it is critical to automate networks and make them as consumable, agile and responsive as the underlying compute and storage elements within the data center. To ensure unrestricted networking across the WAN, a number of data center–WAN integration requirements must be considered in the Data Center Interconnect model.

While SDN-based data center resources can be rapidly provisioned in minutes, WAN connectivity could take several days due to complex coordination needed between different operational groups. Data center networking is predominantly VLAN-based. VLAN handoffs to the WAN require manual provisioning, often in multiple places and without network or service auto-discovery. As a result, the operations process to request WAN connectivity is cumbersome and time-consuming. It involves highly inefficient and labor-intensive processing of change order queues, as well as reconfiguration.

The data center interconnect model needs to be flexible. The technologies used in the data center and in the WAN are typically different, making interworking complex. While VLAN technology is typical in the data center, end-user branch sites are typically connected using several WAN networking technologies, including IP connectivity, Layer 2 VPN and Layer 3 VPN. These sites need to extend connectivity to the cloud service. Furthermore, if

3 BGP MPLS-based Ethernet VPN specification RFC 7432.

4 Nokia's Techzine blog: Ethernet VPN (EVPN) for integrated layer 2-3 services.

the data center operator and WAN operator are the same or different entities, integration also requires the flexibility to allow for the same or different network administrators to operate the data center and WAN equipment.[5]

The integration of data plane and control plane technologies needs to be seamless, ensuring a scalable, distributed network fabric that is as virtualized and readily available as the storage and compute infrastructure. The number of endpoints supporting VMs is set to increase 50 to 100 fold, and they are highly dynamic. For example, multi-tenant applications need to be supported by several workloads and distributed across servers between data centers. Further, VM mobility gives enterprises the ability to move applications between data centers with no perceivable effect on the end user. As VMs are turned up and released from one data center to another, the network services that interconnect them must follow instantaneously and evolve just as dynamically.

For the service provider offering cloud services, the integration should enable innovation, such as combining cloud and business VPN services, as well as service collaboration with third-party data center operators.

Now is the time to innovate, creating a Cloud Interconnect network architecture to take cloud services to next level, addressing each of these integration requirements.

Nokia 7750 SR Data Center Interconnect solution

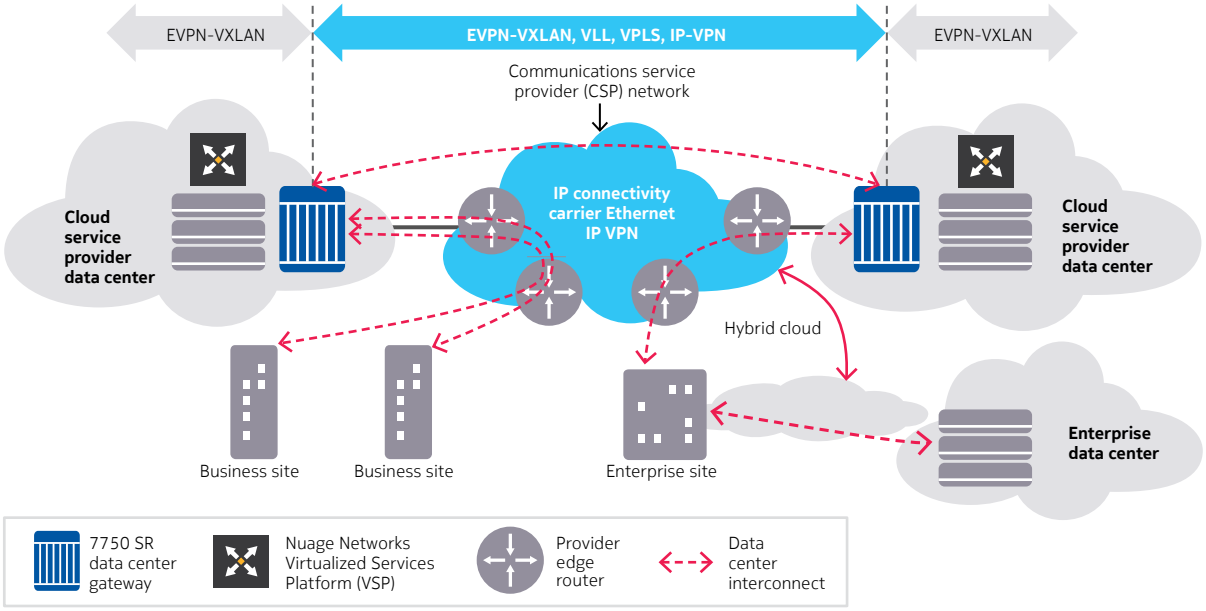
The advancement of technologies such as SDN, VXLAN and EVPNs provides an evolutionary path to enhance data center interconnect. Nokia leverages these advances to deliver the seamless Data Center Interconnect solution. It is based on the 7750 Service Router (SR) in its role as a data center gateway and offers seamless integration with the Nuage Networks Virtualized Services Platform (VSP).[6] The VSP is an SDN solution that virtualizes any data center network infrastructure and automatically establishes connectivity between compute resources upon their creation. This integration assures unrestricted data center networking across the WAN.

Figure 1 illusrates the data center interconnect scenario for a service provider. The network infrastructure is owned by the cloud service provider.

5 Interconnect Solution for EVPN Overlay Networks - draft-etf-bess-dci-evpn-overlay

6 http://www.nuagenetworks.net/products/virtualized-services-platform/

Figure 1. Seamless Data Center Interconnect



Many cloud service providers are actively investing in next-generation cloud data centers to offer value-added cloud services or to implement network virtualization functions (NFVs).

As illustrated in Figure 1, the cloud service provider may be an existing communications service provider (CSP) with its own (or a sister company's) cloud data center. The CSP can extend cloud services to its existing business VPN customers (as part of a service provider private cloud service), or provide hybrid cloud services.

A data center gateway is a key element in the delivery of value-added cloud services. Key functions include service demarcation, the service scale to support thousands of VPN services with separate forwarding and quality of service (QoS), and Internet services for the data center. By participating in data center SDN federation, it enables the auto-instantiation of services between data centers and between data centers and end users and value-added services, including integrated cloud and business VPN services and simplified collaboration with other cloud operators.

This scenario also applies to enterprises implementing a next-generation SDN-based Nuage Networks VSP. Here the Nokia 7750 SR provides data center connectivity along with connectivity to each enterprise branch office. The enterprise WAN infrastructure may be enterprise-owned (that is, the enterprise has fiber or other connectivity between the data center and between the data centers and branch sites), or it may include leased WAN services (IP connectivity or VPN services).

Nokia 7750 Service Router data center gateway

With seamless integration of the data center network and the WAN, the Nokia 7750 SR data center gateway solves the automation challenges and delivers unrestricted data center networking across the WAN. This integration happens at three different levels:

Seamless data plane integration

Using VXLAN, the Nokia 7750 SR is fully integrated into the data center overlay architecture. This provides a seamless data center-WAN data plane, creating a distributed network fabric using any Layer 2 and Layer 3 technology over the WAN. The 7750 SR terminates VM endpoints from the Nuage Networks VSP and does the interworking between the VXLAN overlay tunnels and the IP/MPLS services across the WAN. In this way, the data center fabric is distributed seamlessly across the WAN.

Seamless control plane integration

Using EVPN with MP-BGP, the Nokia 7750 SR is also fully integrated into the data center control plane for a seamless data center-WAN control plane. The cloud-friendly EVPN control plane uses MP-BGP to enable massive scaling for the interconnect with the SDN federation of Nuage Networks VSP data center controllers. This provides seamless peering and federation, auto-discovery and tenant slicing between all virtual data center clusters.

The solution features a number of other benefits, including advertisement control of the WAN MACs to the data center, the proxy-Address Resolution Protocol (ARP)/Neighbor Discovery (ND) protocol function[7] for the protection of Layer 2 domains in the data center from ARP-flooding and unknown flooding, as well as MAC handling features, such as MAC mobility, MAC duplication detection and MAC protection.

Seamless service automation

Seamless interoperability between the 7750 SR data center gateway and the Nuage Networks VSP enables instantaneous automatic attachment of WAN services to the data center domain. The widely deployed Nokia Service Router Operating System (SR OS), common across the 7750 SR and Nuage Networks product portfolio, ensures seamless policy management and policy-based endpoint attachment, delivering the automation provided in today's mobile networks. This process is highly efficient. When a VM is turned on, it is immediately attached to the network, without having to go through a manual

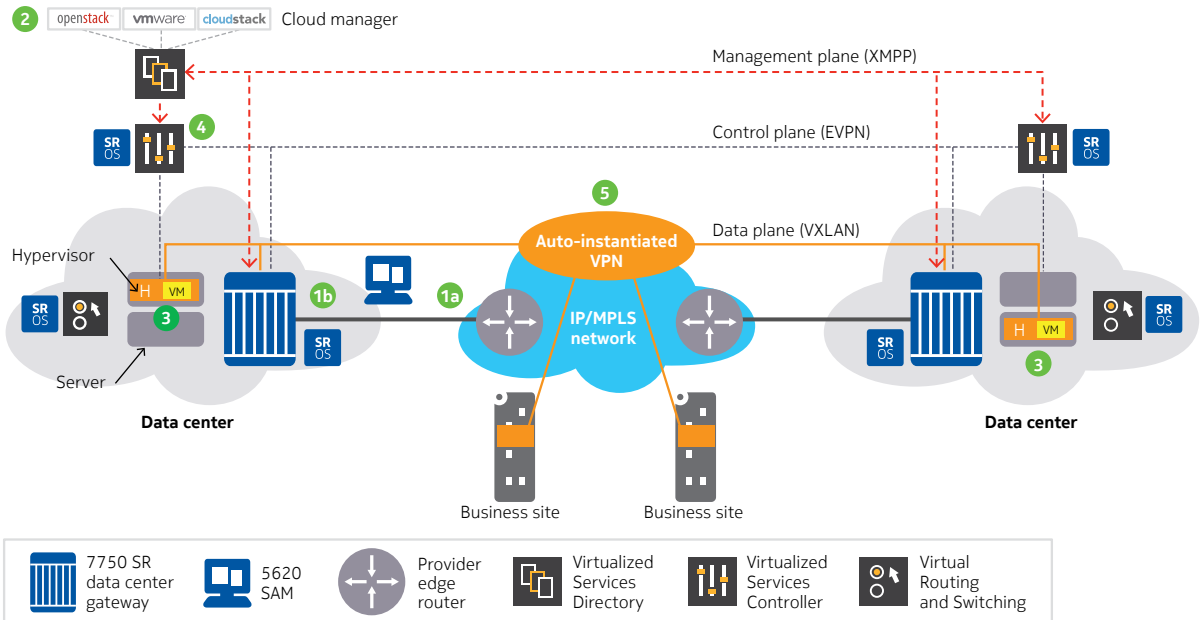
7 Proxy-ARP/ND function in EVPN networks

process for its connectivity to the network. The 7750 SR data center gateway handles the request to provide an automatic attachment to a WAN VPN for the connectivity to remote data centers and users. In addition, the Nokia 7750 SR offers flexible administrative boundaries for operators, supporting decoupled and integrated connectivity models between the gateway and edge router, using Layer 2 and Layer 3 WAN technology.

Automated data center networking across the WAN

The auto-instantiation of applications with tenant subnets extending across the WAN demonstrates the seamless data center interconnect. Leveraging a common SR OS, the Nokia 7750 SR data center gateway is fully integrated into the Nuage Networks VSP. This assures that data center network resources across the WAN can take advantage of an elastic resource pool of capacity that can be consumed and repurposed on demand. Key elements of the Nuage Networks VSP are the Virtualized Services Directory (VSD), the Virtualized Services Controller (VSC) and Virtual Routing and Switching (VRS). Figure 2 illustrates the WAN attachment automation flow.

Figure 2. Application Instantiation across the WAN



The Nokia 7750 SR supports an Extensible Messaging and Presence Protocol (XMPP) interface for provisioning Layer 2 and Layer 3 WAN services by the Nuage Networks VSD.

The steps for instantiating an application across the WAN are as follows:

1a. In the scenario where the cloud operator (managing the Nuage Networks VSD) and IP/MPLS WAN operator are different entities, the solution supports a static plus dynamic integration model. Here the IP/MPLS WAN operator pre-provisions static connectivity and VPN services from their edge router to the 7750 SR data center gateway (this description assumes a decoupled administrative model). This is done through the Nokia 5620 Service Aware Manager (SAM) or Command Line Interface. Through XMPP, the Nuage Networks VSD automatically discovers the services on the 7750 SR, assigns WAN resources and pushes out routing information for the service.

1b. In the scenario where the cloud operator and IP/MPLS WAN operator are the same entity, the solution supports a fully dynamic service integration model. Here the pre-provisioning service parameters on the 7750 SR data center gateway are not required. Once XMPP connectivity has been established, the Nuage Networks VSD automatically discovers and pushes all the required service configuration parameters to the 7750 SR data center gateway.

2. To request compute assets, the cloud manager receives a request that the tenant requires VMs for deployment.

3. The cloud manager issues a request for VM instantiation on the hypervisors, which have resources available. When the VMs are turned up on the hypervisors, the Nuage Networks VRS agent notices the new instantiations across two different data centers. This triggers the Nuage Networks VSP to initiate a network change.

4. Spanning the two different data centers, the Nuage Networks VSC queries the Nuage Networks VSD on policy, and the VSD issues the service template and deploys the policy applicable to the Nuage Networks VRS.

5. The connections between the VMs are then set up. The Nokia 7750 SR, with full integration into the data center control and data planes, and the Nuage Networks VSD auto-instantiate the VPN across the WAN to reach the data center.

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Summary

Nokia is on the forefront of cloud service development. The company is embracing SDN technology and, using open standards, has successfully demonstrated and applied SDN to virtualize the data center. With more than 12 years' experience building the world's largest networks, the Nokia 7750 SR, in its role as a data center gateway, seamlessly interconnects data centers and the WAN over a distributed network fabric with massive scale, efficiency and auto-instantiation.

With support for any Layer 2 and Layer 3 WAN service type and connectivity model, VXLAN and EVPN technologies, along with flexible cloud-WAN service configuration models, the 7750 SR data center gateway fully integrates into the data center for unrestricted data center networking across the WAN. On the strength of the Nuage Networks VSP and the proven SR OS, the Nokia 7750 SR Data Center Interconnect solution enables the data center network to operate seamlessly with the network interconnecting data centers and end users, and delivers the auto-instantiation of applications with tenant subnets that extend across the WAN.

Glossary

ARP	Address Resolution Protocol
ECMP	Equal Cost Multi-Path
EVPN	Ethernet Virtual Private Network
FRR	Fast Reroute
IP VPN	Internet Protocol Virtual Private Network
MAC	Media Access Control
MP-BGP	Multiprotocol-Border Gateway Protocol
MPLS	Multiprotocol Label Switching
ND	Neighbor Discovery
NFV	Network Functions Virtualization
NVO	Network Virtualization Overlay (NVO)
PBB	Provider Backbone Bridging
SDN	Software-Defined Networking
SR OS	Service Router Operating System
STP	Spanning Tree Protocol
UDP	User Datagram Protocol
VLAN	Virtual Local Area Network
VM	Virtual Machine
VSC	Virtualized Services Controller
VSD	Virtualized Services Directory
VSP	Virtualized Services Platform
VRS	Virtual Routing and Services
VXLAN	Virtual Extensible LAN
XMPP	Extensible Messaging and Presence Protocol

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