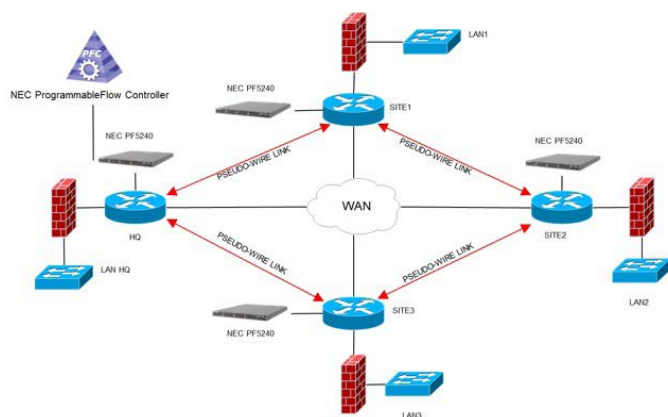


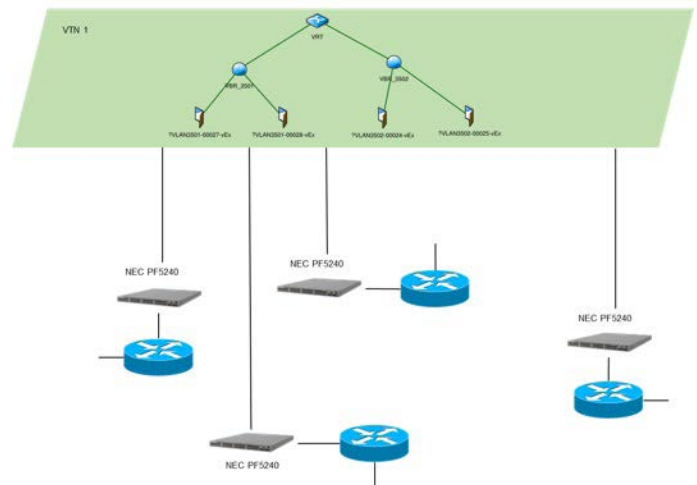
SDN over WAN with NEC ProgrammableFlow

NEC ProgrammableFlow is one of the most recognized Software Defined Networking (SDN) solutions in the market and is based on the OpenFlow protocol. It makes network deployment and management extremely easy, scalable and programmable.

NEC ProgrammableFlow has been specifically developed to address the needs of Campus-wide LAN and Datacenter Networks, and uses the OpenFlow Secure Channel to address every switch in the network. In the case of a multi-site deployment however, it is possible to combine in-band Secure Channel distribution with third party pseudo-wire tunnel technology. Communication between two adjacent switches requires a local connection that is based on a physical link or a pseudo-wire link. This configuration is very useful in the case the SDN infrastructure is to be expanded through remote sites without adding a separate ProgrammableFlow Controller at each site.



With this configuration it is possible to build L2/L3 networks on top of a geographically distributed L3 network, keeping this network separated from the underlying one. This is done thanks to Virtual Tenant Network (VTN) technology, without the need for taking care of overlapping IP addresses, spanning tree protocol configuration and firewall rules. Without this, the activity to create L2/L3 domains that span across different sites is highly error prone, and removing temporary configurations after completing the activities, is difficult and time-consuming.



Moreover, the operation can be led from the Headquarters without involving technical staff at the remote sites, allowing central management and configuration of services and network functions

Key advantages of this ProgrammableFlow solution is:

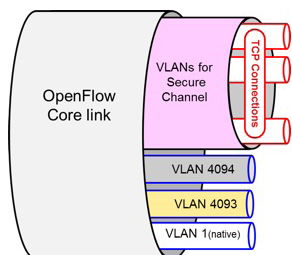
- > Unified network architecture for all sites
- > Centralized and simplified management
- > Enhanced security based on core VTN (Virtual Tenant Network) technology
- > Network virtualization and visualization
- > Agility and programmability

Requirements for its implementation are:

- > Ability to setup pseudo-wire tunnels between remote sites
- > Additional LAN ports on border routers to be reserved one per each tunnel
- > Wideband connection between sites, especially on the main site

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In order to setup the right propagation of the OpenFlow Secure Channel through the core link in an “in-band” configuration, the legacy configuration of the ProgrammableFlow switches must be re-adjusted to the “out-of-band” situation. Some core links will carry not only the core communications, but also the signaling from the ProgrammableFlow Controller to every switch in the infrastructure.



- There are mainly two approaches in order to get to this result:
- > Two VLANs for Secure Channels configuration in “star” open topology (to avoid loops)
 - > Single VLAN for Secure Channels in VRRP and OSPF in full-mesh topology (more resilient)

The pseudo-wire connection can be established with standard routers from third party vendors. Depending on the tunneling technology used for encapsulating the traffic, MTU (Maximum Transmission Unit) adjustment is needed in order to avoid packet fragmentation.

A simple configuration on Cisco routers as an example illustrates this:

<pre>R1# pseudowire-class test encapsulation l2tpv3 protocol none ip local interface GigabitEthernet0/0 (WAN) ! interface GigabitEthernet0/1 no ip address xconnect <R2> 1 encapsulation l2tpv3 manual \ pw-class test l2tp id 2 1</pre>	<pre>R2# pseudowire-class test encapsulation l2tpv3 protocol none ip local interface GigabitEthernet0/0 (WAN) ! interface GigabitEthernet0/1 no ip address xconnect <R1> 1 encapsulation l2tpv3 manual \ pw-class test l2tp id 1 2</pre>
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Some customization is needed on the ProgrammableFlow switches. For example QoS must be set up on links carrying Secure Channels to avoid disconnection of the switch or high

latency, especially on links with reduced bandwidth. QoS must be applied to all the ports, bringing together Openflow Data link and Openflow Secure Channel, in order to correctly prioritize signaling packets.

```
interface gigabitethernet 0/47
 switchport mode trunk
 switchport trunk allowed vlan 201
 qos-queue-group InbandSecureChannel
!
interface gigabitethernet 0/48
 switchport mode trunk
 switchport trunk allowed vlan 202
 qos-queue-group InbandSecureChannel
!
interface vlan 201
 ip address 10.0.1.103 255.255.255.0
 ip qos-flow-group SecureChannel1 in
!
interface vlan 202
 ip address 10.0.2.103 255.255.255.0
 ip qos-flow-group SecureChannel2 in
!
qos-queue-list InbandSecureChannel pq
!
ip qos-flow-list SecureChannel1
 10 qos ip 10.0.1.0 0.0.0.255 10.0.1.0 0.0.0.255 action cos 7 replace-user-priority 7
!
ip qos-flow-list SecureChannel2
 10 qos ip 10.0.2.0 0.0.0.255 10.0.2.0 0.0.0.255 action cos 7 replace-user-priority 7
!
```

Keeping Secure Channels out-of-band is the best approach, as this configuration separates data traffic from signaling traffic. Moreover, two separate channels are mandatory to secure High Availability and real-time response of the controller to partial network outages. In the case out-of-band is not applicable, in-band Secure Channel propagation is also possible and performs well. Extension of this configuration over WAN can be established with third party routers with pseudo-wire tunnel features.

As pioneer of SDN solutions using OpenFlow protocol, NEC operates at the forefront of technology and with its ProgrammableFlow makes network deployment and management extremely easy, secure, scalable and programmable.

About NEC Corporation - NEC Corporation is a leader in the integration of IT and network technologies that benefit businesses and people around the world. By providing a combination of products and solutions that cross utilize the company’s experience and global resources, NEC’s advanced technologies meet the complex and ever-changing needs of its customers. NEC brings more than 100 years of expertise in technological innovation to empower people, businesses and society. For more information, visit NEC at <http://www.nec.com>

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