Solution brief

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The bridge to possible

Cisco Extends Enterprise-grade Data Center Networking to AWS Outposts

Contents

Overview

Cisco provides scalable data center network solutions for customers today to automate their hybrid-cloud interconnects and extend multitenancy and network segmentation designs between multiple on-premises data centers and AWS regions. With the addition of AWS Outposts to the AWS product offering, Cisco customers now can use Cisco's hybrid-cloud solution to easily connect AWS Outposts instances to their existing fabrics and leverage consistent policy-driven automation to connect workloads residing on premises and/or in the AWS cloud.

Customer requirements

Cisco customers have deployed Cisco Nexus® 9000–based data-center fabrics widely over the last five years, taking advantage of Cisco innovations in network automation, security, and assurance. As their adoption of hybrid-cloud strategy accelerates, customers demand more flexibility to deploy application workloads on premises or in the AWS cloud while being able to access IT resources on either side. Two key requirements need to be addressed:

1. Deliver a seamless hybrid-cloud experience by extending enterprise-grade intersite network connectivity, workload segmentation, and workload mobility designs.
2. Leverage consistent policy model and governance across on-premises ACI fabrics and AWS instances in the cloud.
3. Provide cloud experience on premises through AWS Outposts for application workloads that demand low latency, storage-intensive local I/O, and data locality to meet regulatory requirements.

Solution

With the advent of AWS Outpost, customers now have the flexibility to extend Cisco data-center networking solutions to AWS Outposts in two modes:

1. Connect AWS Outposts instances to Cisco Nexus–9000 based fabrics – basic connectivity.
   a. Cisco Nexus 9000–based fabric – Cisco NX-OS mode.
   b. Cisco Nexus 9000–based fabric – Cisco ACI™ mode.
2. Consistent policy-based network extension and segmentation between workloads on premises and in AWS cloud – ACI mode and Cloud ACI extension to AWS.

AWS Outposts overview

AWS Outposts is a fully managed service that extends AWS infrastructure, AWS services, APIs, and tools to virtually any data center, colocation space, or on-premises facility for a truly consistent hybrid experience. AWS Outposts is ideal for workloads that require low-latency access to on-premises systems, local data processing, or local data storage. AWS customers can use AWS Outposts to launch Amazon Elastic Compute Cloud (EC2) instances and Amazon Elastic Block Store (EBS) volumes locally and run a range of AWS services locally on Outposts or connect to a broad range of services available in the local AWS region.

AWS Outposts will be connected to the customer's data-center network. While Outposts itself are fully managed by AWS, easy connectivity and integration with the on-premises network is the key for successful deployment and operation of AWS Outposts. Cisco provides our customers an easy solution to connect AWS Outposts to their on-premises Cisco Nexus networks in either NX-OS or ACI mode. If ACI is the operational model of choice, our customers will also be able to extend the benefits of the Cloud ACI solution to AWS Outposts so that they can use a consistent policy model to manage the network connectivity to the AWS cloud, to AWS Outposts, and across their data centers.

Each AWS Outpost has two Top-of-Rack (ToR) switches called Outposts Network Devices (ONDs). The two Outpost Network Devices, Outpost Network Device 1 and Outpost Network Device 2, are connected to two access switches in the customer data-center network with a Link Aggregation Control Protocol (LACP) port channel of multiple member links. Layer-3 connectivity is established over VLAN SVI interfaces or Layer-3 subinterfaces with 802.01q encapsulation over the port channel. Border Gateway Protocol (BGP) routing runs over the Layer-3 links between AWS Outposts and the customers data-center network.

Each Outpost Network Device establishes two BGP sessions with the customer data-center network, one for the service link datapath and the other for the local datapath. The service link datapath is to provide the connectivity between the Outpost and its parent AWS region. Therefore, it needs to be part of the Layer-3 routing space that is eventually connected to the external routing domain to reach the AWS region. The local datapath is to provide the internal connectivity between the AWS Outpost and the customer data center. It is recommended to keep these two datapaths in two separate VRFs for better route segmentation and control between the external and internal routing spaces.

AWS Outposts in data centers with Cisco Nexus 9000 NX-OS mode

When customers choose to deploy and operate their data-center networks with Cisco Nexus 9000 Series Switches in NX-OS mode, they can build a traditional two or three-tier network using the technologies like Spanning Tree Protocol (STP) and Virtual Port Channel (vPC), but a more modern network design is to leverage BGP EVPN to build an IP-based VXLAN overlay data-center fabric. VXLAN EVPN fabrics provide enterprise grade scale, multitenancy, and workload mobility. The remainder of this section discusses the required configurations to deploy AWS Outposts to an on-premises data center in both scenarios.

A traditional three-tier data-center network consists of access, aggregation, and core tiers. The switches on the access tier normally are deployed in vPC pairs to provide redundant connectivity for endhosts and network devices that are connected to the network. The network between the access tier and the aggregation tier can be Layer 2 running STP and vPC, or Layer 3. The network between the aggregation tier and the core tier is normally Layer 3.

Figure 1 shows a three-tier network with the demarcation of Layer 2 and Layer 3 on the access tier. The switches on the access tier are in vPC pairs. It shows two typical connectivity topologies for connecting AWS Outposts to an vPC pair of access switches. In example (a), each AWS Outpost Network Device is connected to both access switches via a vPC port channel. In example (b), each AWS Outpost Network Device is connected to one access switch via a non-vPC port channel. In either example, each AWS Outpost Network Device only runs BGP routing with one access switch in a vPC pair. Although it is recommended to keep the service link datapath and the local datapath in two separate VRFs for better route segmentation and control, multi-VRF routing in a traditional two or three-tier data-center network requires a hop-by-hop VRF-lite routing configuration, which is not a common practice due to its operational complexity. Both examples have the two datapaths in the default VRF.

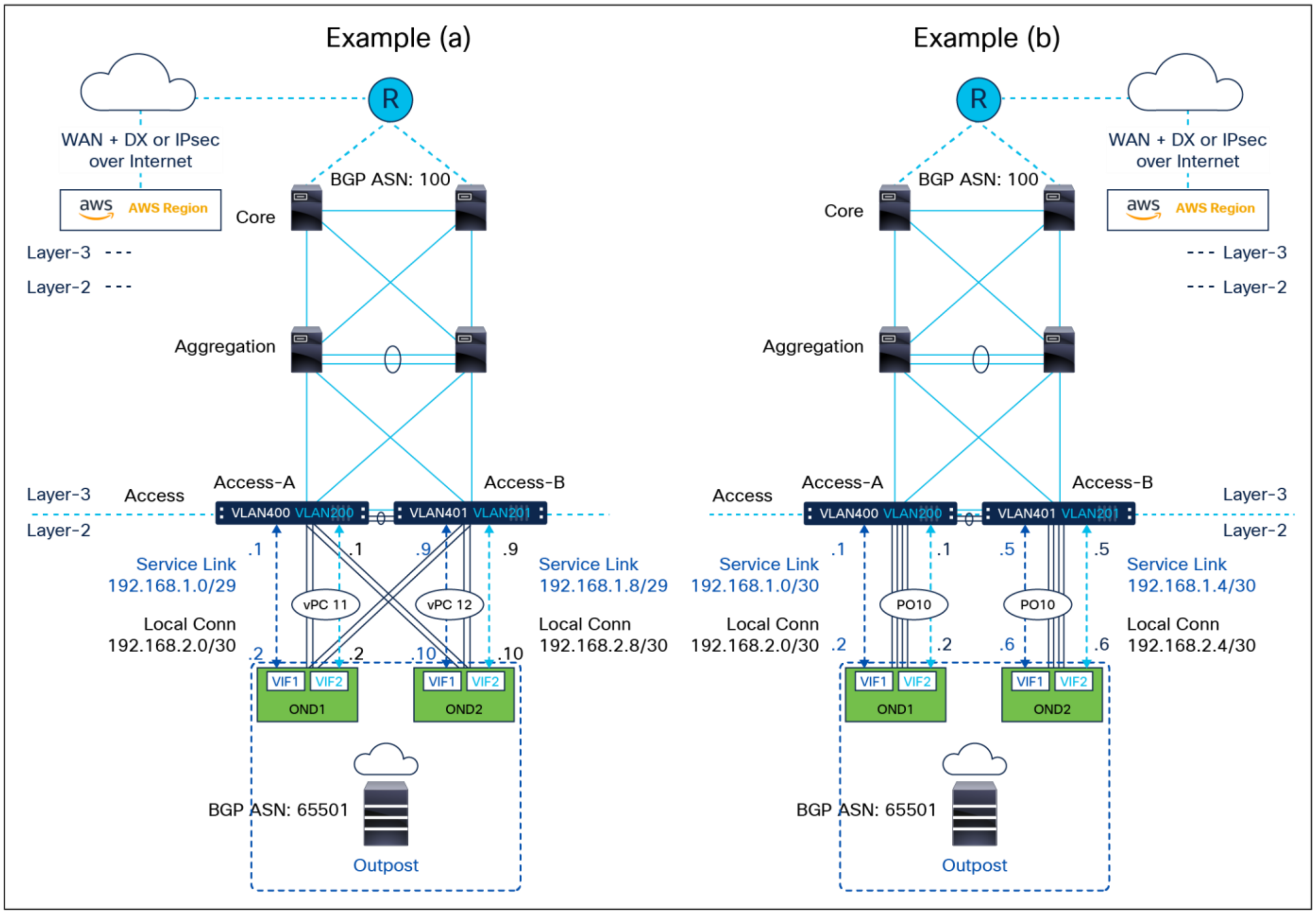


Figure 1.
AWS Outposts on a Cisco Nexus 9000 NX-OS three-tier data-center network

In the examples shown in Figure 1, the following designs are used:

- In example (a), AWS Outpost Network Device 1 is connected to both Access-A and Access-B switches via a vPC port channel (PO11). Outpost Network Device 2 is connected to both Access-A and Access-B switches via a vPC port channel (PO12).
- In example (b), AWS Outpost Network Device 1 is connected to Access-A via a port channel (PO10 on Access-A). Outpost Network Device 2 is connected to Access-B via a port channel (PO10 on Access-B). Note: This option relies on Outposts' internal high-availability mechanisms to deliver resilient network connectivity.

- In both examples, the on-premises network is in BGP ASN 100. The AWS Outposts is in BGP ASN 65501.
- In both examples, AWS Outpost Network Device 1 has two BGP peerings with Access-A, one in VLAN 400 for service-link connectivity and the other in VLAN 200 for local connectivity. AWS Outpost Network Device 2 has two BGP peerings with Access-B, one in VLAN 401 for service link connectivity and the other in VLAN 201 for local connectivity.

Tables 1 and 2, below, show the relevant configurations for the AWS Outposts deployment on both Access-A and Access-B in example (a) and (b), respectively. It assumes that the vPC configuration between the two switches has been implemented. For a reference on basic vPC configuration, use the following configuration guide: https://www.cisco.com/c/en/us/td/docs/switches/datacenter/nexus9000/sw/6-x/interfaces/configuration/guide/b_Cisco_Nexus_9000_Series_NX-OS_Interfaces_Configuration_Guide/configuring_vpcs.pdf.

Table 1. Required access-switch configurations in example (a) for AWS Outposts deployment

Access-A	Access-B
`interface port-channel11`	`interface port-channel11`
`  switchport`	`  switchport`
`  switchport mode trunk`	`  switchport mode trunk`
`  switchport trunk allowed vlan 200,400`	`  switchport trunk allowed vlan 200,400`
`  vpc 11`	`  vpc 11`
`interface port-channel12`	`interface port-channel12`
`  switchport`	`  switchport`
`  switchport mode trunk`	`  switchport mode trunk`
`  switchport trunk allowed vlan 201,401`	`  switchport trunk allowed vlan 201,401`
`  vpc 12`	`  vpc 12`
`interface Ethernet1/1-2`	`interface Ethernet1/1-2`
`  switchport`	`  switchport`
`  switchport mode trunk`	`  switchport mode trunk`
`  switchport trunk allowed vlan 200,400`	`  switchport trunk allowed vlan 200,400`
`  channel-group 11`	`  channel-group 11`
`  no shutdown`	`  no shutdown`
`interface Ethernet1/3-4`	`interface Ethernet1/3-4`
`  switchport`	`  switchport`
`  switchport mode trunk`	`  switchport mode trunk`
`  switchport trunk allowed vlan 201,401`	`  switchport trunk allowed vlan 201,401`
`  channel-group 12`	`  channel-group 12`
`  no shutdown`	`  no shutdown`
`interface Vlan200`	`interface Vlan200`

Access-A	Access-B
no shutdown	no shutdown
ip address 192.168.2.1/29	ip address 192.168.2.3/29
interface Vlan201	interface Vlan201
no shutdown	no shutdown
ip address 192.168.2.11/29	ip address 192.168.2.9/29
interface Vlan400	interface Vlan400
no shutdown	no shutdown
ip address 192.168.1.1/29	ip address 192.168.1.3/29
interface Vlan401	interface Vlan401
no shutdown	no shutdown
ip address 192.168.1.11/29	ip address 192.168.1.9/29
router bgp 100	router bgp 100
router-id 1.1.1.1	router-id 2.2.2.2
neighbor 192.168.1.2 **←AWS Outpost Network Device 1 service link datapath**	neighbor 192.168.1.10 **←AWS Outpost Network Device 2 service link datapath**
remote-as 65501	remote-as 65501
address-family ipv4 unicast	address-family ipv4 unicast
neighbor 192.168.2.2 **← AWS Outpost Network Device 1 local datapath**	neighbor 192.168.2.10 **←AWS Outpost Network Device 2 service local datapath**
remote-as 65501	remote-as 65501
address-family ipv4 unicast	address-family ipv4 unicast

Table 2. Required access-switch configurations in example (b) for AWS Outposts deployment

Access-A	Access-B
interface port-channel10	interface port-channel10
switchport	switchport
switchport mode trunk	switchport mode trunk
switchport trunk allowed vlan 200,400	switchport trunk allowed vlan 201,401
interface Ethernet1/1-4	interface Ethernet1/1-4
switchport	switchport
switchport mode trunk	switchport mode trunk
switchport trunk allowed vlan 200,400	switchport trunk allowed vlan 201,401
channel-group 10	channel-group 10
no shutdown	no shutdown

Access-A	Access-B

`interface Vlan200`
`  no shutdown`
`  ip address 192.168.2.1/30`
	`interface Vlan201`
	`  no shutdown`
	`  ip address 192.168.2.5/30`

`interface Vlan400`
`  no shutdown`
`  ip address 192.168.1.1/30`
	`interface Vlan401`
	`  no shutdown`
	`  ip address 192.168.1.5/30`

`router bgp 100`
`  router-id 1.1.1.1`
`  neighbor 192.168.1.2` **←AWS Outpost Network Device 1 service link datapath**
`    remote-as 65501`
`    address-family ipv4 unicast`
`  neighbor 192.168.2.2` **← AWS Outpost Network Device 1 local datapath**
`    remote-as 65501`
`    address-family ipv4 unicast`
	`router bgp 100`
	`  router-id 2.2.2.2`
	`  neighbor 192.168.1.6` **←AWS Outpost Network Device 2 service link datapath**
	`    remote-as 65501`
	`    address-family ipv4 unicast`
	`  neighbor 192.168.2.6` **←AWS Outpost Network Device 2 service local datapath**
	`    remote-as 65501`
	`    address-family ipv4 unicast`

Note: In this example, PO10 on both access switches are not vPC port-channel; they are local to Access-A or Access-B. VLAN 200, 201, 400, and 401 are non-vPC VLANs. VLAN 200 and 400 are only on Access-A while VLAN 201 and 401 are only on Access-B. They must be removed from the allowed VLAN list of the vPC peer link.

Figure 2 illustrates a typical topology and design to connect AWS Outposts to an NX-OS VXLAN fabric. The two Outpost Network Devices of an AWS Outpost are connected to two different leaf switches of the on-premises data-center network via LACP port channels. Two Layer-3 subinterfaces are configured, one for the internal local datapath and the other for the service link datapath to the AWS region. They are in two different VRFs. BGP peer is established between each of the subinterfaces and AWS Outposts. The service link connectivity to the AWS region goes through the existing border-leaf switch that runs dynamic routing with the customer organization network outside of the data-center network to provide external connectivity to WAN or the Internet.

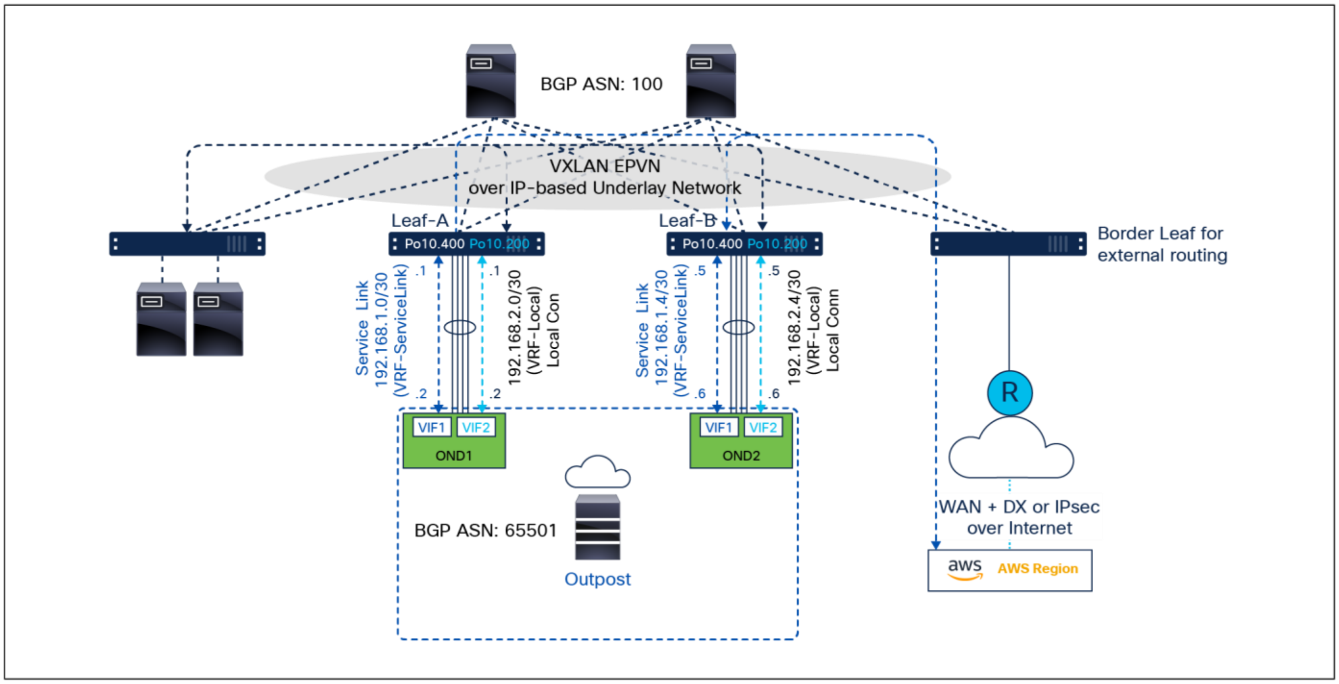


Figure 2.
AWS Outposts on Cisco Nexus 9000 NX-OS VXLAN fabric

In the example shown in Figure 2, the following design is used:

- Two VRFs, vrf-local and vrf-servicelink, are created for the local routing and for Outpost service link connectivity to the AWS region, respectively.
- The port channel 10 is configured on each leaf switch.
- Subinterface Po10.400 is configured for Layer-3 connectivity with AWS Outpost Network Device VIF1 (IP addresses are indicated in Figure 1) for the service link. It is in vrf-servicelink.
- Subinterface Po10.200 is configured for Layer-3 connectivity with AWS Outpost Network Device VIF2 (IP addresses are indicated in Figure 2) for local connectivity. It is in vrf-local.
- The on-premises network is in BGP ASN 100.
- The AWS Outpost is in BGP ASN 65501.
- The leaf switches are running BGP EVPN as a control protocol.
- BGP routing between the leaf switches and the AWS Outpost Network Devices runs in the IPv4 unicast address-family in vrf-servicelink and vrf-local, respectively. The BGP-learned VRF routes are advertised into the L2VPN EVN address-family for further propagation to the rest of the network in the corresponding VRF.

The table below shows the required Cisco Nexus 9000 leaf switch configuration for the above design, including the two VRFs, port-channel interface and subinterfaces, and BGP routing with the AWS Outpost Network Devices.

Note: A detailed explanation of the switch configuration is not in the scope of this document. Refer to the following configuration guide for Cisco Nexus 9000 Series Switch BGP EVPN configuration: https://www.cisco.com/c/en/us/td/docs/switches/datacenter/nexus9000/sw/93x/vxlan/configuration/guide/b-cisco-nexus-9000-series-nx-os-vxlan-configuration-guide-93x.html.

Table 3. Required leaf-switch configuration for AWS Outposts deployment in Cisco Nexus 9000 VXLAN EVPN fabric

Configuration on Leaf-A	Configuration on Leaf-B

vrf context vrf-local **<- VRF for AWS Outposts local datapath**
  vni 60200
  rd auto
  address-family ipv4 unicast
    route-target import 100:60200
    route-target export 100:60200
    route-target both auto evpn
vrf context vrf-servicelink **<- VRF for AWS Outposts service link datapath**
  vni 60400
  rd auto
  address-family ipv4 unicast
    route-target import 100:60400
    route-target export 100:60400
    route-target both auto evpn
 	
interface Ethernet1/1-4
  channel-group 10
  no shutdown
 	
interface port-channel10
 	
interface port-channel10.200
  description outpost local connectivity
  encapsulation dot1q 200
  vrf member vrf-local
  ip address 192.168.2.1/30
  no shutdown
 	
interface port-channel10.400
  description outpost service-link
  encapsulation dot1q 400
  vrf member vrf-servicelink
  ip address 192.168.1.1/30
	vrf context vrf-local **<- VRF for AWS Outposts local datapath**
	  vni 60200
	  rd auto
	  address-family ipv4 unicast
	    route-target import 100:60200
	    route-target export 100:60200
	    route-target both auto evpn
	vrf context vrf-servicelink **<- VRF for AWS Outposts service link datapath**
	  vni 60400
	  rd auto
	  address-family ipv4 unicast
	    route-target import 100:60400
	    route-target export 100:60400
	    route-target both auto evpn
	
	interface Ethernet1/1-4
	  channel-group 10
	  no shutdown
	
	interface port-channel10
	
	interface port-channel10.200
	  description outpost local connectivity
	  encapsulation dot1q 200
	  vrf member vrf-local
	  ip address 192.168.2.5/30
	  no shutdown
	
	interface port-channel10.400
	  description outpost service-link
	  encapsulation dot1q 400
	  vrf member vrf-servicelink
	  ip address 192.168.1.5/30

Configuration on Leaf-A	Configuration on Leaf-B
no shutdown	no shutdown
router bgp 100	router bgp 100
log-neighbor-changes	log-neighbor-changes
address-family ipv4 unicast	address-family ipv4 unicast
address-family l2vpn evpn	address-family l2vpn evpn
vrf vrf-servicelink	vrf vrf-servicelink
address-family ipv4 unicast	address-family ipv4 unicast
advertise l2vpn evpn	advertise l2vpn evpn
neighbor 192.168.1.2 **<- Outpost Network Device 1 VIF1**	neighbor 192.168.1.2 **<- Outpost Network Device 2 VIF1**
remote-as 65501	remote-as 65501
address-family ipv4 unicast	address-family ipv4 unicast
default-originate **<-Optional**	default-originate **<- Optional**
vrf vrf-local	vrf vrf-local
address-family ipv4 unicast	address-family ipv4 unicast
advertise l2vpn evpn	advertise l2vpn evpn
neighbor 192.168.2.2 **<- Outpost Network Device 1 VIF2**	neighbor 192.168.2.6 **<- Outpost Network Device 2 VIF2**
remote-as 65501	remote-as 65501
address-family ipv4 unicast	address-family ipv4 unicast

AWS Outposts in data centers with Cisco Nexus 9000 ACI mode

With Cisco ACI, customers can enable workload mobility, automate service chaining functions, and enforce their security posture in a consistent manner across on-premises ACI fabrics.

Figure 3 shows the typical topology and design for connecting AWS Outposts to a Cisco ACI fabric network. The physical topology is similar to that of NX-OS VXLAN EVPN fabric, but the Layer-3 subinterfaces and BGP routing are provisioned as part of an L3Out on the ACI fabric.

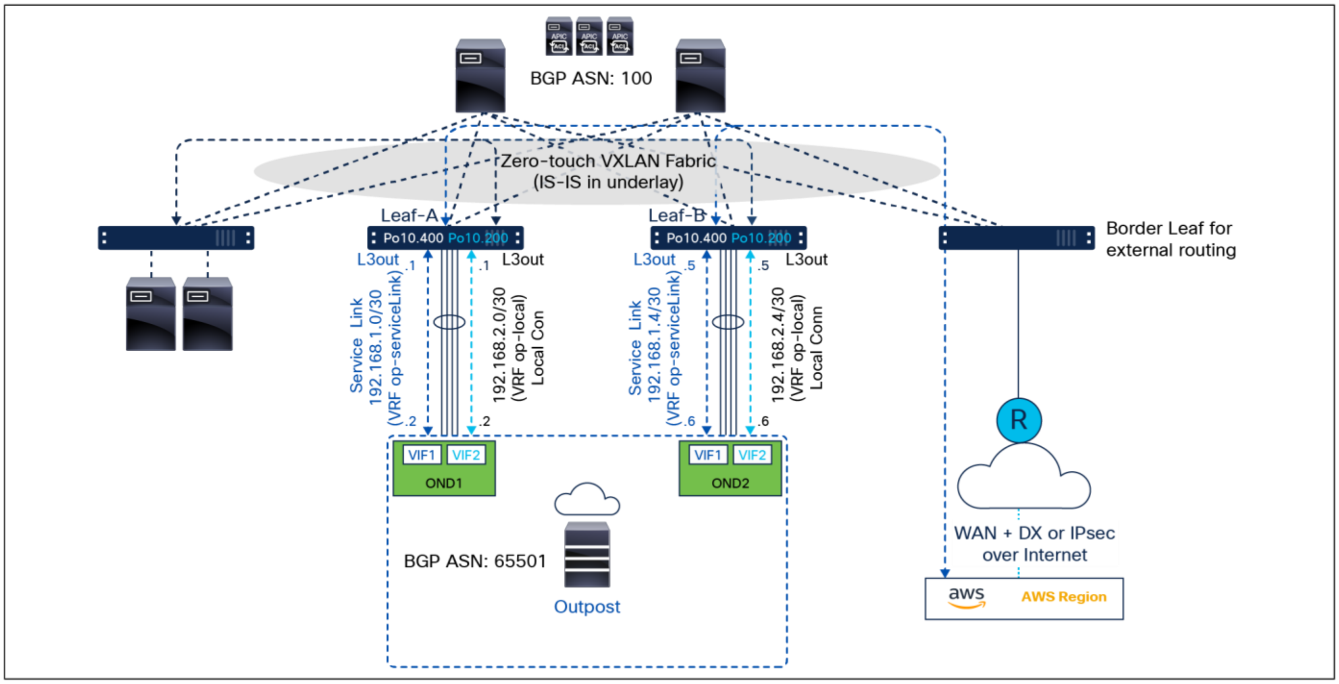


Figure 3.
AWS Outposts on Cisco ACI fabric network

In the example shown in Figure 3, the following two L3Out objects are defined, one for the AWS Outposts local datapath, and the other for the AWS Outposts service link datapath. They are in VRF op-local and VRF op-servicelink, respectively. The configuration is centrally defined on the Application Policy Infrastructure Controller (APIC).

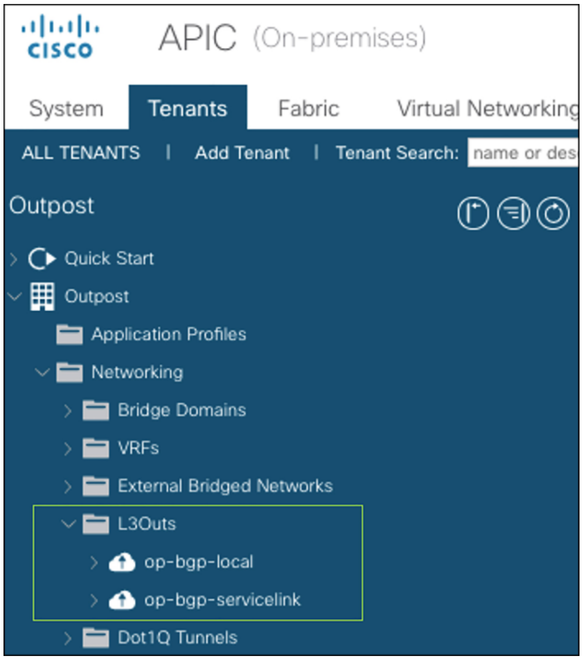
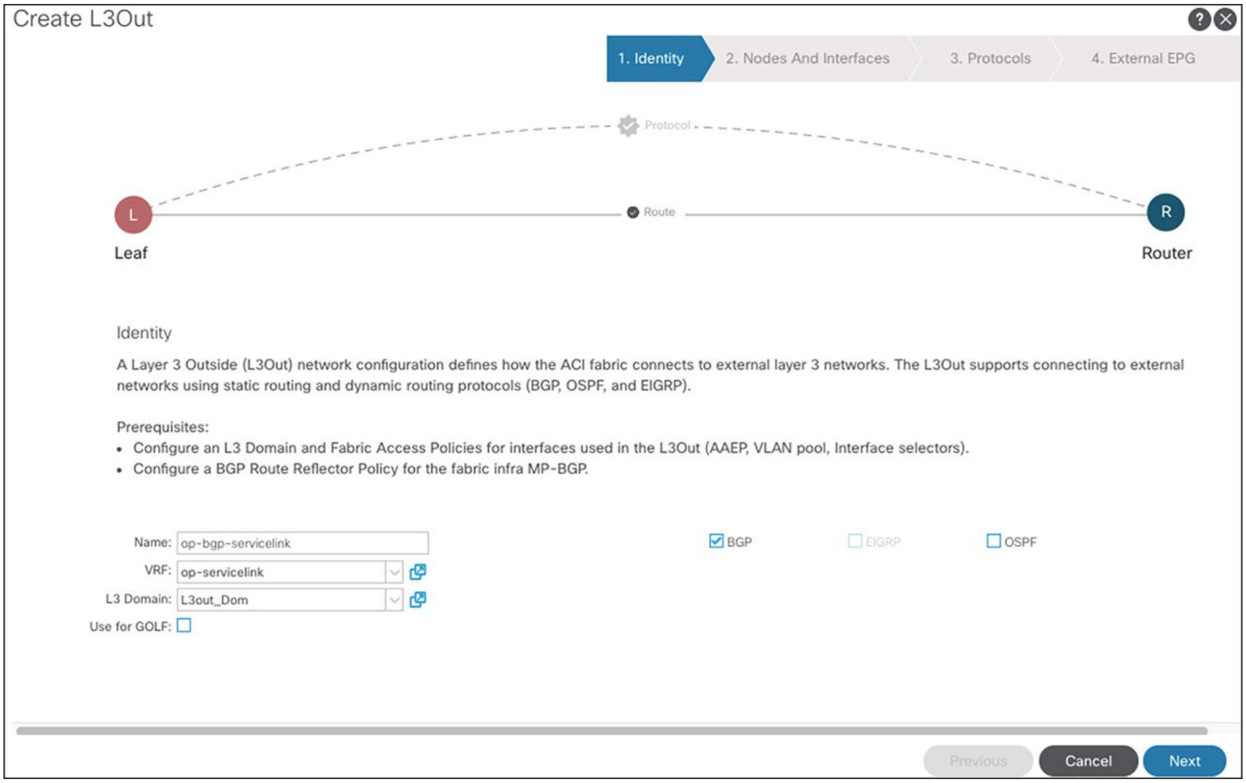


Figure 4 shows the steps to configure the L3Out op-bgp-servicelink on APIC GUI.



Identity

A Layer 3 Outside (L3Out) network configuration defines how the ACI fabric connects to external layer 3 networks. The L3Out supports connecting to external networks using static routing and dynamic routing protocols (BGP, OSPF, and EIGRP).

Prerequisites:

- Configure an L3 Domain and Fabric Access Policies for interfaces used in the L3Out (AAEP, VLAN pool, Interface selectors).
- Configure a BGP Route Reflector Policy for the fabric infra MP-BGP.

Name: op-bgp-servicelink

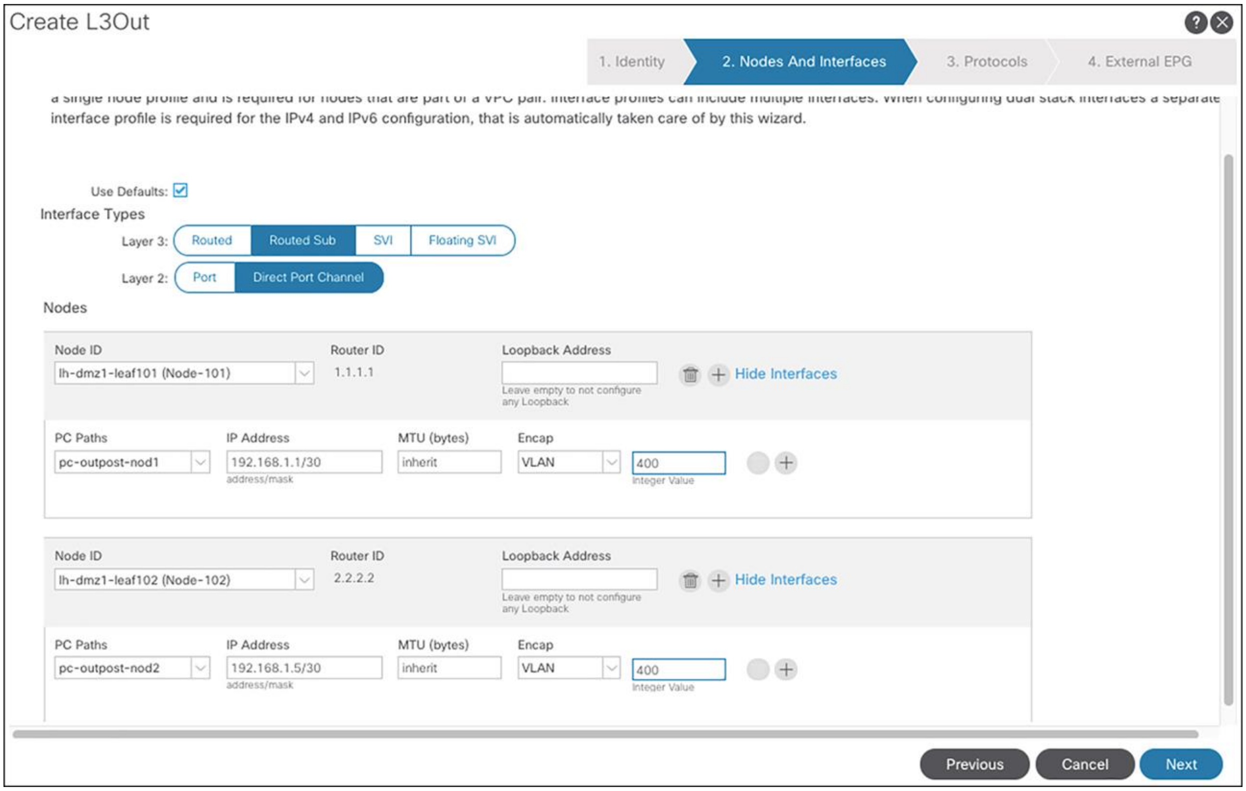
VRF: op-servicelink

L3 Domain: L3out_Dom

Use for GOLF: □

☑ BGP □ EIGRP □ OSPF

Figure 4.
Configuring the L3Out op-bgp-servicelink



a single node profile and is required for nodes that are part of a vPC pair. Interface profiles can include multiple interfaces. When configuring dual stack interfaces a separate interface profile is required for the IPv4 and IPv6 configuration, that is automatically taken care of by this wizard.

Use Defaults: ☑

Interface Types

Layer 3: Routed | Routed Sub | SVI | Floating SVI

Layer 2: Port | Direct Port Channel

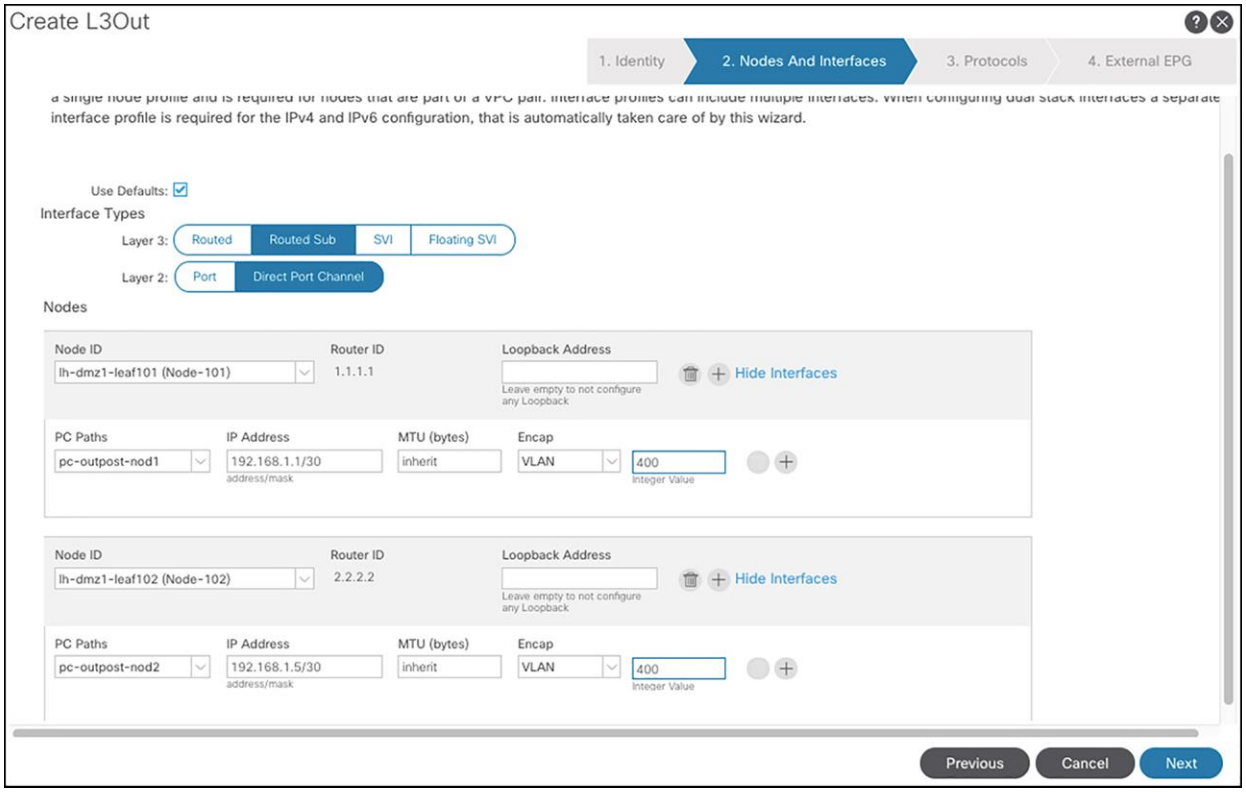
Nodes

Node ID	Router ID	Loopback Address
lh-dmz1-leaf101 (Node-101)	1.1.1.1	Leave empty to not configure any Loopback

PC Paths	IP Address	MTU (bytes)	Encap	
pc-outpost-nod1	192.168.1.1/30 address/mask	inherit	VLAN	400 Integer Value

Node ID	Router ID	Loopback Address
lh-dmz1-leaf102 (Node-102)	2.2.2.2	Leave empty to not configure any Loopback

PC Paths	IP Address	MTU (bytes)	Encap	
pc-outpost-nod2	192.168.1.5/30 address/mask	inherit	VLAN	400 Integer Value



Create L3Out

a single node profile and is required for nodes that are part of a vPC pair. Interface profiles can include multiple interfaces. When configuring dual stack interfaces a separate interface profile is required for the IPv4 and IPv6 configuration, that is automatically taken care of by this wizard.

Use Defaults: ☑

Interface Types

Layer 3: Routed | **Routed Sub** | SVI | Floating SVI

Layer 2: Port | **Direct Port Channel**

Nodes

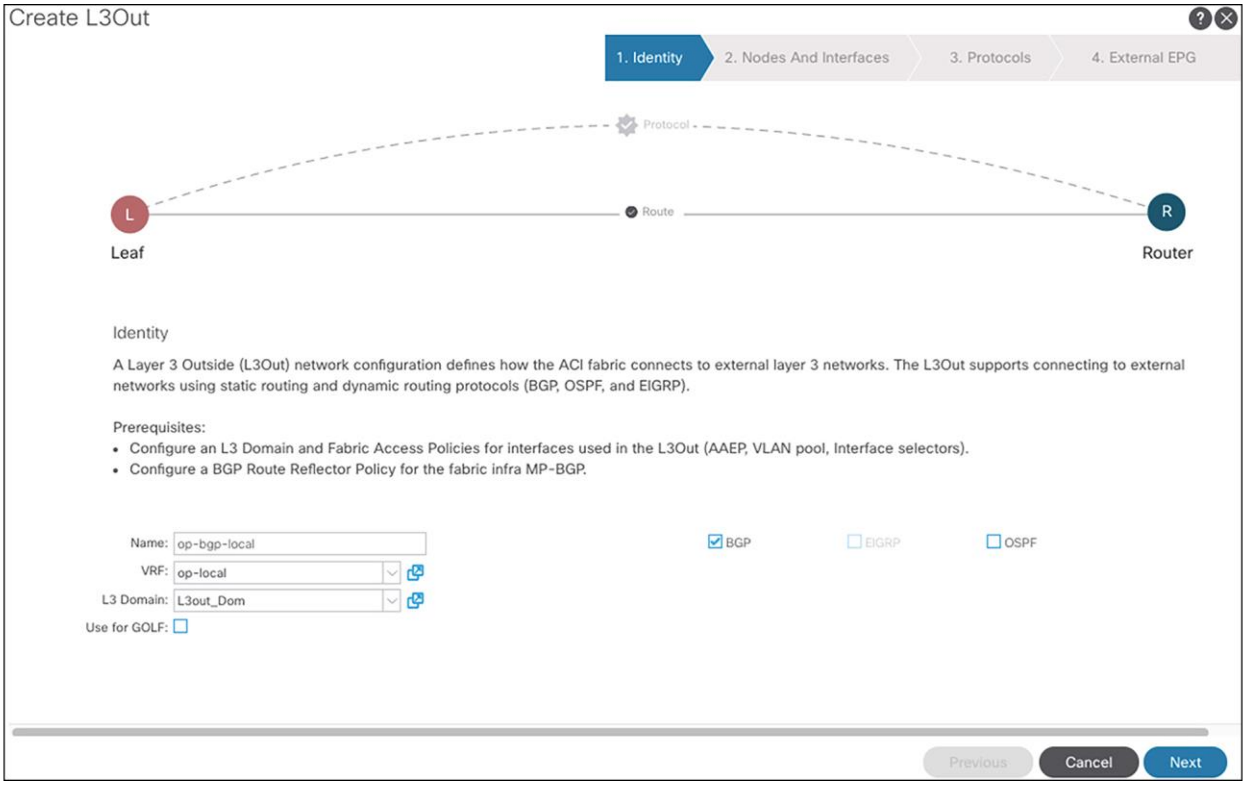
Node ID	Router ID	Loopback Address
lh-dmz1-leaf101 (Node-101)	1.1.1.1	Leave empty to not configure any Loopback

PC Paths	IP Address	MTU (bytes)	Encap	
pc-outpost-nod1	192.168.1.1/30 address/mask	inherit	VLAN	400 Integer Value

Node ID	Router ID	Loopback Address
lh-dmz1-leaf102 (Node-102)	2.2.2.2	Leave empty to not configure any Loopback

PC Paths	IP Address	MTU (bytes)	Encap	
pc-outpost-nod2	192.168.1.5/30 address/mask	inherit	VLAN	400 Integer Value

Figure 5 shows the steps to configure the L3Out op-bgp-local on APIC GUI.



Create L3Out

Identity

A Layer 3 Outside (L3Out) network configuration defines how the ACI fabric connects to external layer 3 networks. The L3Out supports connecting to external networks using static routing and dynamic routing protocols (BGP, OSPF, and EIGRP).

Prerequisites:

- Configure an L3 Domain and Fabric Access Policies for interfaces used in the L3Out (AAEP, VLAN pool, Interface selectors).
- Configure a BGP Route Reflector Policy for the fabric infra MP-BGP.

Name: op-bgp-local

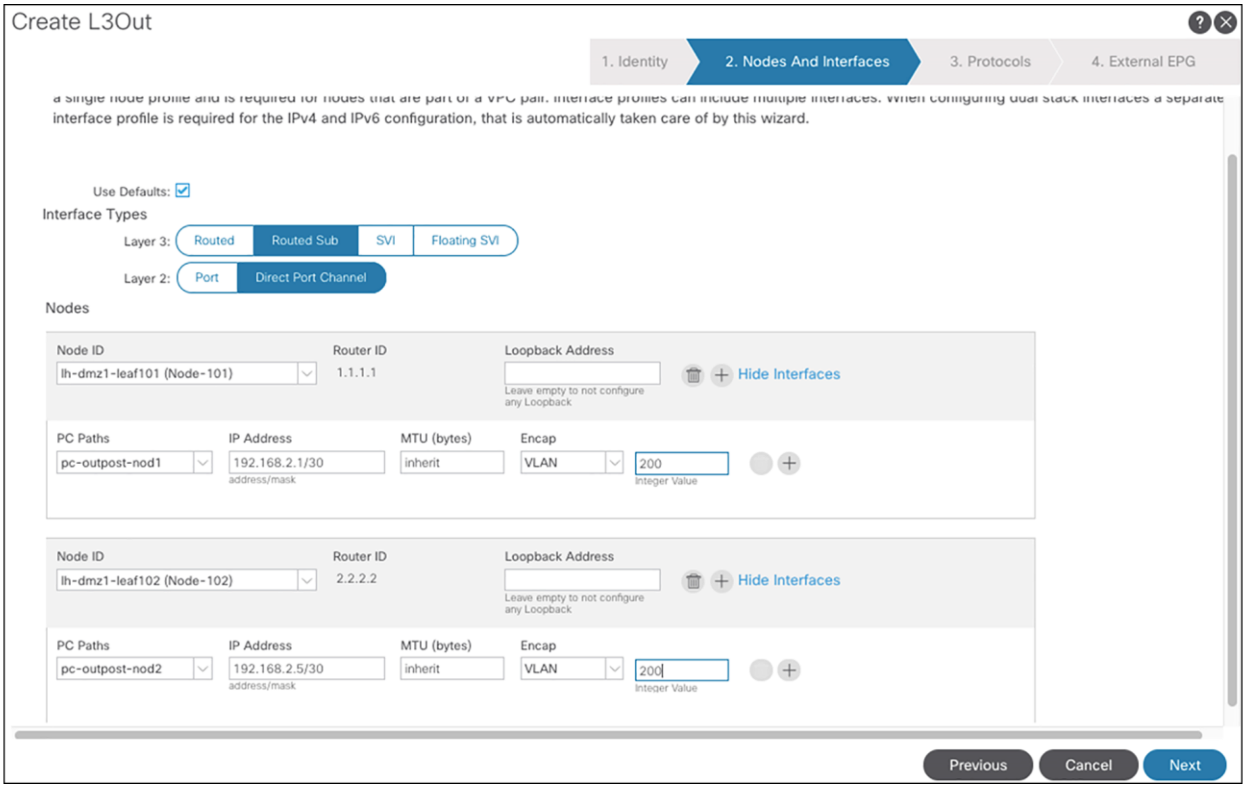
VRF: op-local

L3 Domain: L3out_Dom

Use for GOLF: □

☑ BGP □ EIGRP □ OSPF

Figure 5.
Configuring L3out op-bgp-local



a single node profile and is required for nodes that are part of a vPC pair. Interface profiles can include multiple interfaces. When configuring dual stack interfaces a separate interface profile is required for the IPv4 and IPv6 configuration, that is automatically taken care of by this wizard.

Use Defaults: ☑

Interface Types

Layer 3: Routed | [✓ Routed Sub] | SVI | Floating SVI

Layer 2: Port | [✓ Direct Port Channel]

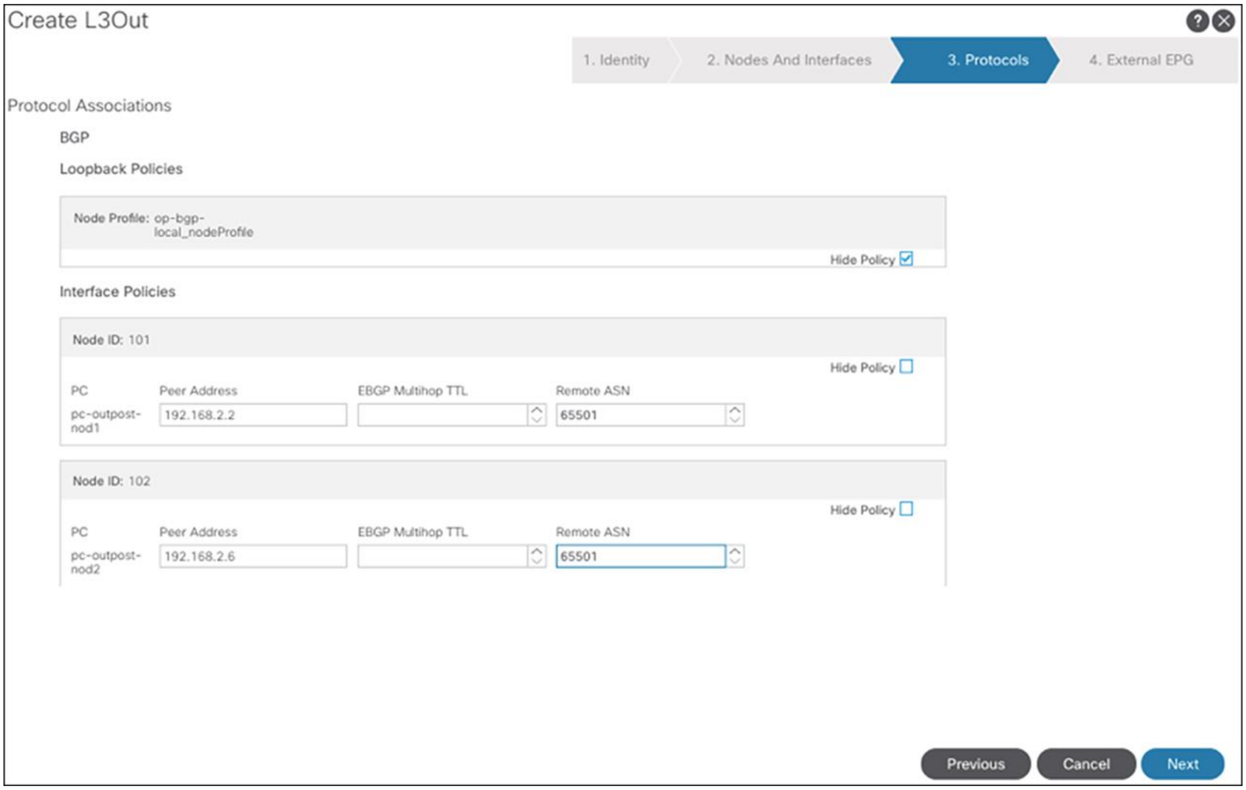
Nodes

Node ID: lh-dmz1-leaf101 (Node-101)
Router ID: 1.1.1.1
Loopback Address: (Leave empty to not configure any Loopback)

PC Paths	IP Address	MTU (bytes)	Encap	
pc-outpost-nod1	192.168.2.1/30	inherit	VLAN	200

Node ID: lh-dmz1-leaf102 (Node-102)
Router ID: 2.2.2.2
Loopback Address: (Leave empty to not configure any Loopback)

PC Paths	IP Address	MTU (bytes)	Encap	
pc-outpost-nod2	192.168.2.5/30	inherit	VLAN	200



Protocol Associations

BGP

Loopback Policies

Node Profile: op-bgp-local_nodeProfile

Hide Policy ☑

Interface Policies

Node ID: 101

Hide Policy □

PC	Peer Address	EBGP Multihop TTL	Remote ASN
pc-outpost-nod1	192.168.2.2		65501

Node ID: 102

Hide Policy □

PC	Peer Address	EBGP Multihop TTL	Remote ASN
pc-outpost-nod2	192.168.2.6		65501

Note: The above shows the configuration using the APIC GUI interface. Customers can also use the APIC API to program the fabric.

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