White Paper

Service Graph Design with Cisco Application Centric Infrastructure

Contents

Introduction

Cisco® Application Centric Infrastructure (Cisco ACI™) technology enables you to insert Layer 4 through Layer 7 (L4-L7) functions using a concept called a service graph. This document describes the service graph concept and how to design for service insertion using the service graph.

With the service graph, Cisco ACI introduces innovations at both the data-plane and management levels.

Using the service graph, Cisco ACI can redirect traffic between security zones to a firewall or a load balancer, without the need for the firewall or the load balancer to be the default gateway for the servers. Cisco ACI can selectively send traffic to L4-L7 devices based, for instance, on the protocol and the Layer 4 port. Firewall inspection can be transparently inserted in a Layer 2 domain with almost no modification to existing routing and switching configurations. Cisco ACI also allows you to increase the capacity of L4-L7 devices by creating a pool of devices to which Cisco ACI can distribute traffic.

With the service graph, Cisco ACI introduces changes in the operation model. A configuration can now include not only network connectivity—VLANs, IP addresses, and so on—but also the configuration of Access Control Lists (ACLs), load-balancing rules, and so on.

This approach differs from the traditional operation model of service insertion. Prior to Cisco ACI, the fabric configuration consisted only of **connectivity** for firewalls and load balancers. With Cisco ACI and the service graph, it can include the **configuration** of firewalls and load balancers.

With the service graph, security and load-balancing administrators can define security and load-balancing policies using the management tool of their preferred vendor. The Cisco Application Policy Infrastructure Controller (APIC) administrator can then associate these policies with the traffic path that the administrator defined in Cisco ACI.

When to Use the Service Graph

You can deploy firewalls and load balancers with Cisco ACI with or without a service graph. To decide whether or not you should use the service graph technology, you need to understand the problem that the service graph solves and the available operational models.

Cisco designed the service graph technology to automate the deployment of an L4-L7service in the network. Cisco ACI doesn’t provision the L4-L7 device itself, but it can configure it as part of the same configuration that creates tenants, bridge domains, and Endpoint Groups (EPGs).

Cisco ACI offers three management models for the service graph:

- Network policy mode (or unmanaged mode): In this mode, Cisco ACI configures only the network portion of the service graph on the Cisco ACI fabric, which means that Cisco ACI doesn't push configurations to the L4-L7 device.
- Service policy mode (or managed mode): In this mode, Cisco ACI configures the fabric and the L4-L7 device VLANs, and the APIC administrator enters the L4-L7 device configurations through APIC.
- Service manager mode: In this mode, the firewall or load-balancer administrator defines the L4-L7 policy, Cisco ACI configures the fabric and the L4-L7 device VLANs, and the APIC administrator associates the L4-L7 policy with the networking policy.

You may find the service graph useful if you want to create a portal from which administrators can create and decommission network infrastructure, including firewalls and load balancers. In this case, Cisco ACI can help automate the configuration of the firewalls and load balancers so long as they already exist as either physical or virtual devices. For this use case, you may want to use the service policy mode or service manager mode.

With the service graph in service policy mode, the configuration of the L4-L7 device is part of the configuration of the entire network infrastructure, so you need to consider the security and load-balancing rules at the time that you configure network connectivity for the L4-L7 device. This approach is different from that of traditional service insertion in that if you don't use the service graph, you can configure the security and load-balancing rules at a different time than when you configure network connectivity.

With the service manager mode, the interactions with the L4-L7 device depend on the vendor management tool. Cisco ACI references a policy defined on the L4-L7 management tool. This tool may let you make changes to the firewall or load-balancer configurations without the need to redeploy the service graph.

If all you need is a topology with a perimeter firewall that controls access to the data center, and if this firewall is not decommissioned and provisioned again periodically, you should use the network policy mode deployment.

The service graph concept is considered an extension to the concept of a contract, so by default it operates with the model of an external and an internal interface. If you need to use the service graph for a firewall with multiple network edges (or DMZs), you need to reuse the service graph multiple times between each pair of interfaces. For this type of deployment you may find it more convenient to integrate the firewall without using the service graph.

The service graph offers several advantages and some disadvantages. Two of the biggest advantages are the capability to redirect traffic (which works in all deployment modes: network policy mode, service policy mode, and service manager mode) and the capability to automate VLAN allocation between the L4-L7 device and the fabric.

Service graph redirect offers many advantages:

- It eliminates the need to make the firewall or load balancers the default gateway.
- It avoids the need for more complex types of designs such as the Virtual Routing and Forwarding (VRF) instance–L4-L7–VRF design.
- It avoids to need to split Layer 2 domains (bridge domains) to insert, for instance, a firewall in the path.
- It allows you to redirect only a subset of the traffic based on the protocol and port.
- It allows you to filter traffic between security zones in the same Layer 2 domain (bridge domain).
- It allows you to scale the performance of the L4-L7 device by distributing traffic to multiple devices.

The service graph offers these advantages:

- The service graph can redirect traffic to L4-L7 devices, eliminating the need for more complex designs.
- The service graph automatically manages VLAN assignments.
- The service graph automatically connects virtual Network Interface Cards (vNICs).
- The configuration template can be reused multiple times.
- The service graph provides a more logical view and offers an application-related view of services.
- The service graph provides a better model for sharing a device across multiple departments.
- The service graph collects health scores from the device or service.
- The service graph collects statistics from the device.
- The service graph updates ACLs and pools automatically with endpoint discovery.

The service graph in service policy mode has some disadvantages:

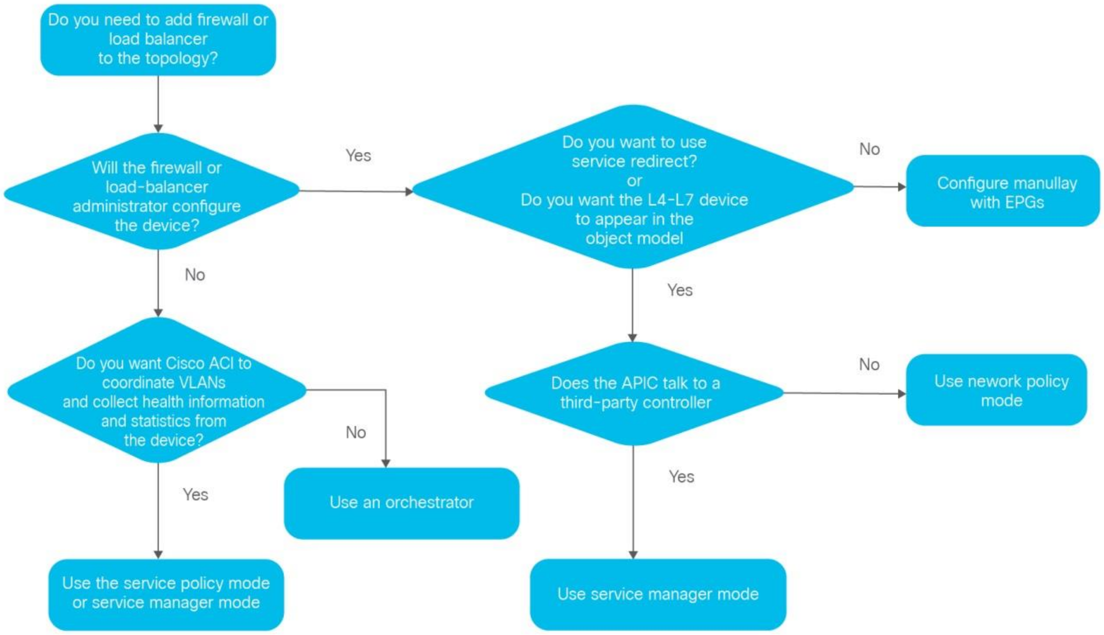
- The operational model is orientated toward automation.
- The number of configuration parameters that the APIC administrator needs to manage can be overwhelming and not practical for deployments that require frequent configuration adjustments.

In summary, when choosing whether to use a service graph or traditional bridge-domain stitching, you need to take into account the following points:

- Do I need the firewall and load balancers to be configured dynamically through the APIC, or should a different administrator configure them? In the second case, you should use network policy mode or service manager mode.
- Do I need to be able to commission, use, and decommission a firewall or a load balancer frequently, as in a cloud service, or will these services be used in the same way for a long period of time? In the first case, you should use service policy mode or service manager mode. In the second case, you should use network policy mode or service manager mode.
- Does my design require only two interfaces for load balancers and firewalls, or does it require a multiple-leg and multiple-DMZ configuration? In the second case, you may find it more convenient not to use the service graph, but to instead perform service insertion based on manual configuration of EPGs and bridge domains.

The flowchart in Figure 1 shows how to choose the service graph deployment method.

Figure 1. Service Graph Decision Flowchart


Do you need to add firewall or load balancer to the topology?
Will the firewall or load-balancer administrator configure the device?
Yes
Do you want to use service redirect? or Do you want the L4-L7 device to appear in the object model
No
Configure manullay with EPGs
No
Yes
Do you want Cisco ACI to coordinate VLANs and collect health information and statistics from the device?
Does the APIC talk to a third-party controller
No
Use nework policy mode
No
Use an orchestrator
Yes
Yes
Use the service policy mode or service manager mode
Use service manager mode

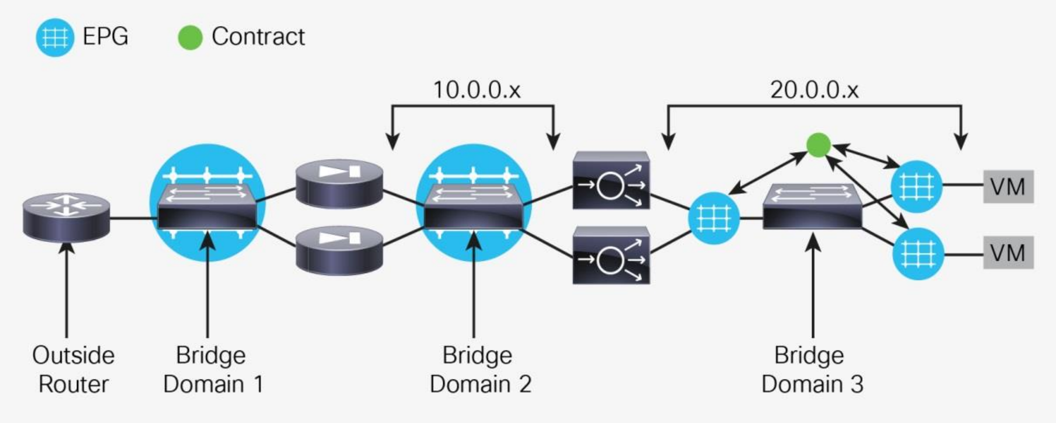
Service Insertion with Cisco ACI

In Cisco ACI, you also can configure service insertion without a service graph.

To do so, you need to create multiple bridge domains that operate just like VLANs, and you can configure EPGs to connect virtual or physical appliances.

Figure 2 shows a simple multinode service insertion design. The configuration consists of multiple bridge domains and EPGs. Bridge Domain 1 has an EPG to which the router and the firewall outside interface connect. Bridge Domain 2 has one EPG to connect the inside interface of the firewalls and the client-side interface of the Application Delivery Controller (ADC) device. Bridge Domain 3 has an EPG for the server-side interface of the ADC device and multiple EPGs for the servers, and the EPGs are connected through contracts.

Figure 2. Manual Configuration of Service Insertion



Service Graphs, Functions, and Rendering

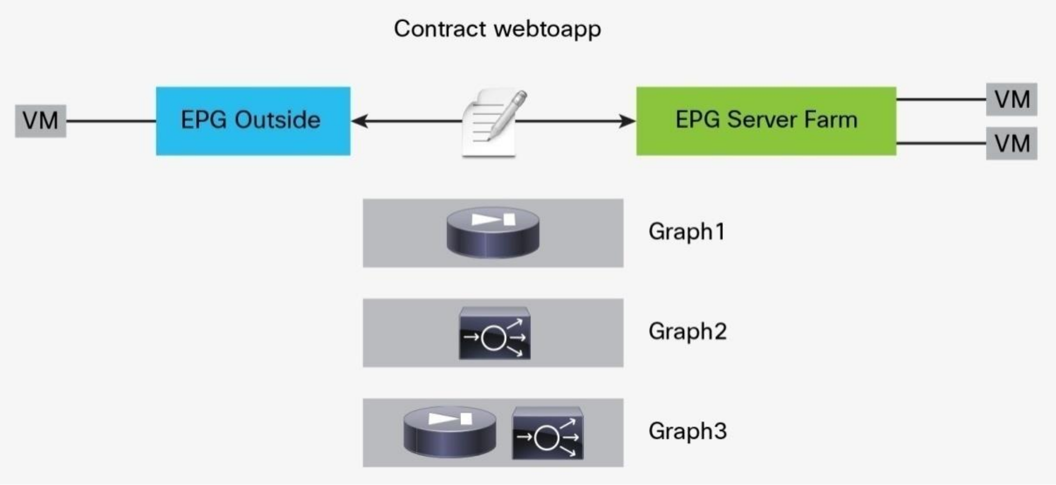
The concept of a service graph differs from the concept of service insertion. The service graph specifies that the path from one EPG to another EPG must pass through certain functions:

- With service graph redirect, the service graph effectively steers traffic to the L4-L7 device.
- With the other service graph deployment modes, the service graph doesn't steer traffic to the L4-L7 device, but it creates contracts to prevent the traffic from going directly from one EPG to the other. Only traffic that goes through the L4-L7 device is allowed.

As Figure 3 illustrates, the service graph is associated with a contract between two EPGs. In the figure, the contract webtoapp can be associated with Graph1, which consists of a single firewall device; or with Graph2, which consists of a single ADC device; or with Graph3, which consists of a sequence of a firewall and an ADC device.

A contract could also have a single contract with multiple "subjects" (that is, combinations of Layer 4 ports), each associated with a different graph.

Figure 3. The Service Graph Is Inserted Between EPGs Through a Contract



The APIC translates the definition of the service graph into a path through firewalls and load balancers. This process is called rendering. This rendering is based on the graph template and information provided by the user about the bridge domain to which a firewall or a load balancer should connect, as well as on the user-configured firewalls and load balancers that a given contract and graph template should use.

With the service graph, the following building blocks of the forwarding path configurations are decoupled:

- Information about each L4-L7 device: management address and the ports to which the device is connected
- Definition of the type of graph: the type of L4-L7 devices used, the mode (go-to or go-through, one-arm, or redirect), and the number of devices
- Configuration used for a given contract and graph
- L4-L7 devices known to Cisco ACI that should be used for the contract and graph
- Overlay bridge domain to which the L4-L7 device connect for each contract and graph instantiation

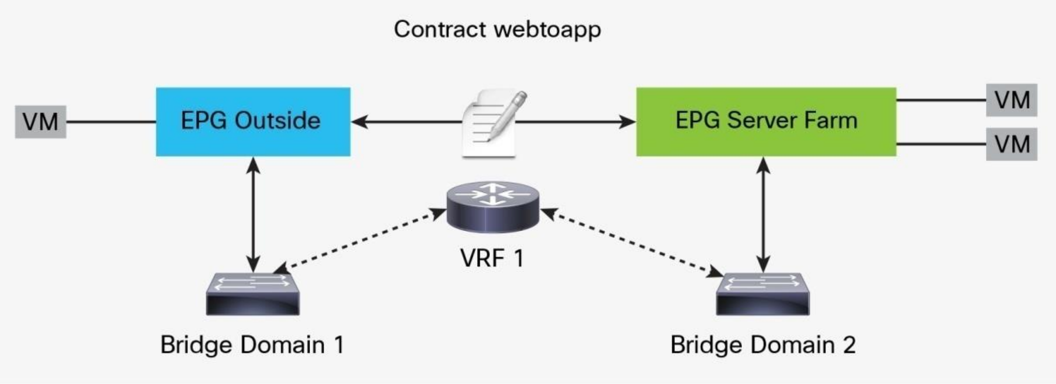
With a service graph, if you have an existing firewall deployed in a graph and you want to replace it, you simply need to define where the new firewall is connected and how it should be managed. Then you specify the configuration that defines the firewall used to render the graph (in the device selection policy). Cisco ACI will then configure the new firewall just like the existing one, and the graph will now point to the new firewall.

Even if the service graph provides an abstract definition of the sequence of functions required between any two EPGs, some data-plane infrastructure needs to be in place beforehand: for instance, the bridge domain (or bridge domains) to which the L4-L7 device connects.

To deploy a service graph between EPGs in go-to or go-through mode, you need to provision a sequence of bridge domains and potentially more than one VRF instance.

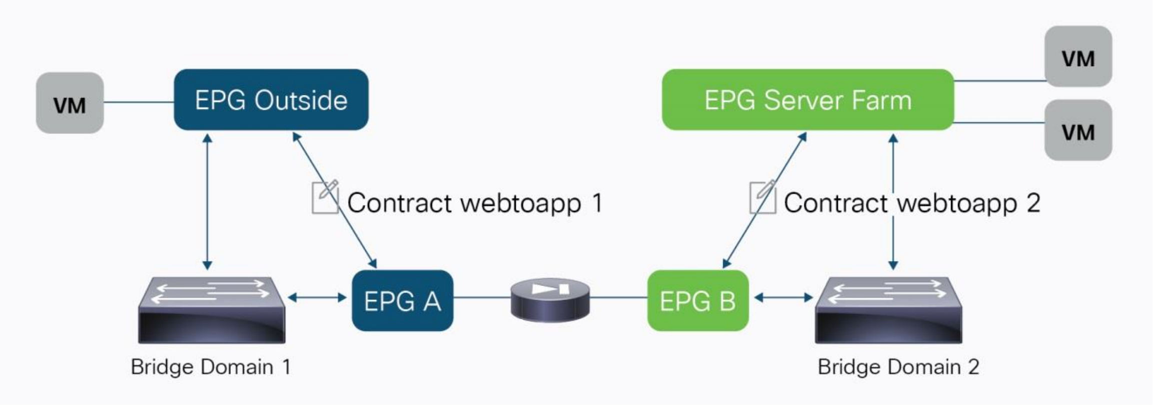
As Figure 4 shows, with go-to or go-through mode, the EPG outside and EPG server farm must be in different bridge domains for the service graph to work. In addition, the bridge domains must have a relationship with a VRF instance to be consistent with the object model.

Figure 4. With the L4-L7 Device in Go-To or Go-Through Mode, EPGs Must Be in Different Bridge Domains



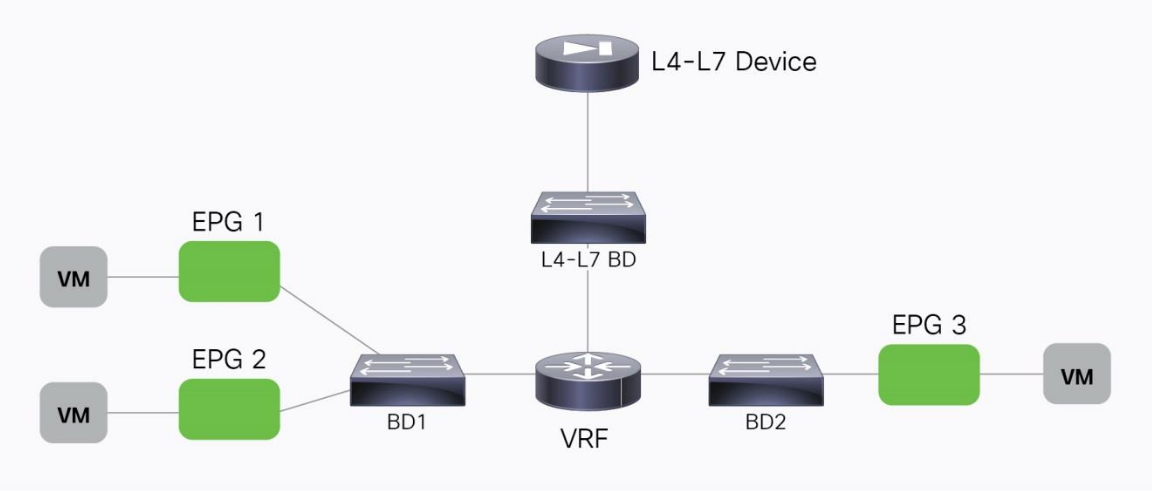
The rendering involves allocation of the necessary VLANs between the L4-L7 device and the bridge domains, and the forwarding mode of the bridge domains must be compatible with the forwarding mode of the L4-L7 device. Cisco ACI creates EPGs to which the L4-L7 device connects, and it creates contracts to enable communication to and from the L4-L7 device (Figure 5).

Figure 5. ACI Creates Shadow EPGs and Contracts to Allow Communication with the L4-L7 Device



When you use service graph redirect, the L4-L7 device doesn't need to be connected directly to the bridge domains in which the endpoints reside. In addition, the endpoints do not need to be in different bridge domains for the traffic to traverse a L4-L7 device. Figure 6 shows a firewall connected to the L4-L7 bridge domain. Virtual machines are on BD1 and BD2. With service graph redirect, you can configure traffic from EPG1 to EPG2 to be sent through the firewall first, as well as traffic from EPG1 or EPG 2 to EPG3. You can also define a rule that says that only traffic on port 80 between EPG1 and EPG2 has to go through the firewall, whereas other traffic can go directly between EPG1 and EPG2.

Figure 6. With the L4-L7 Device in Policy Based Redirect (PBR) Mode, EPGs Can Be in the Same Bridge Domain



One difference between the service graph in go-to or go-through mode and the redirect option is that in the first case the contract in the graph allows traffic to go through the L4-L7 device, but you have to set up separate bridge domains to have routing or bridging forward the traffic to the L4-L7 device. With redirect, the contract rule forwards traffic to the firewall regardless of the routing and bridging lookup results.

L4-L7 Parameters

With Cisco ACI, the provisioning of services is not limited to network connectivity on the Cisco ACI fabric side, but it includes the optional capability to configure the firewall and the load balancers with all the necessary rules for load balancing and security. This configuration is performed either through Representational State Transfer (REST) calls to the APIC or from the GUI of the APIC. The configurations that need to be pushed to the L4-L7 devices are called L4-L7 parameters.

The L4-L7 parameters include the following:

- Port channels
- Interface IP addresses and masks
- Routing configuration
- Virtual IP address configuration
- Server farm configuration
- ACL configuration

These parameters do not assign VLANs to physical interfaces and vNICs. Instead, Cisco ACI dynamically allocates VLANs.

The device package defines which L4-L7 parameters can be configured from the APIC. The vendor of the firewall or ADC appliance defines the syntax of these L4-L7 parameters, and this syntax reflects the syntax used by the firewall or ADC administrator when the device is configured directly.

The configuration of L4-L7 parameters from the APIC can be tedious, so Cisco ACI provides the function profile feature, which allows you to define a collection of L4-L7 parameters that you can use when you apply a service graph template. Function profiles can also be prepopulated by the management system of the L4-L7 device vendor.

When you use the service graph function of Cisco ACI in service policy mode, you enter all the configurations for the fabric and for the service device as part of the same L4-L7 configuration process. As a result, you must enter L4-L7 parameters that configure the firewall and the load balancer. This process can be time consuming, particularly if you want to decommission a device and redeploy it in a different way. The function profile solves this problem.

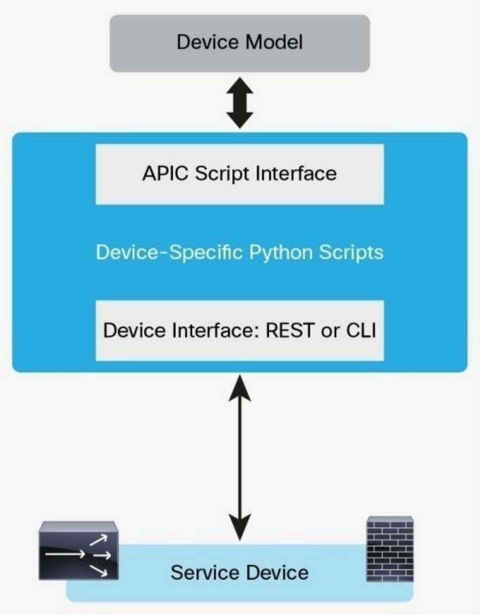
With a function profile, you can create a collection of L4-L7 configuration parameters that you can use when you apply a service graph template.

If you are using the service graph with a device package, the APIC communicates with the L4-L7 device to configure it as part of the rendering of the graph.

The APIC communicates with the firewalls or load balancers to render the graph defined by the user. For Cisco ACI to be able to talk to firewalls and load balancers, it needs to speak to their APIs. The administrator needs to install plug-ins called device packages on the APIC to enable this communication.

As shown in Figure 7, the device package includes a description of the device and lists the parameters it is exposing for the APIC configuration. The device package includes the scripts that allow Cisco ACI to talk to this device.

Figure 7. The Device Package Enables Communication from Cisco APIC to the L4-L7 Device



With the device package, the vendor of the L4-L7 device makes certain settings configurable through the APIC. For instance, these settings may be the most used functions of the L4-L7 device. With this type of device package, the L4-L7 device can be configured almost entirely from the APIC. An example of such an implementation is the Cisco Adaptive Security Appliance (ASA) device package with policy orchestration and fabric insertion.

The APIC will clear any device global configuration that is supported from APIC that has not been pushed from the APIC. For instance, the APIC does not clear the management IP address, login credentials, or any configuration that the device needs to be operational that is not supported through the APIC.

Certain device packages make only network configurations available through the APIC, leaving L4-L7 configurations to be managed directly on the device. An example of this type of device package is the Cisco ASA device package that allows fabric insertion only.

Management Model

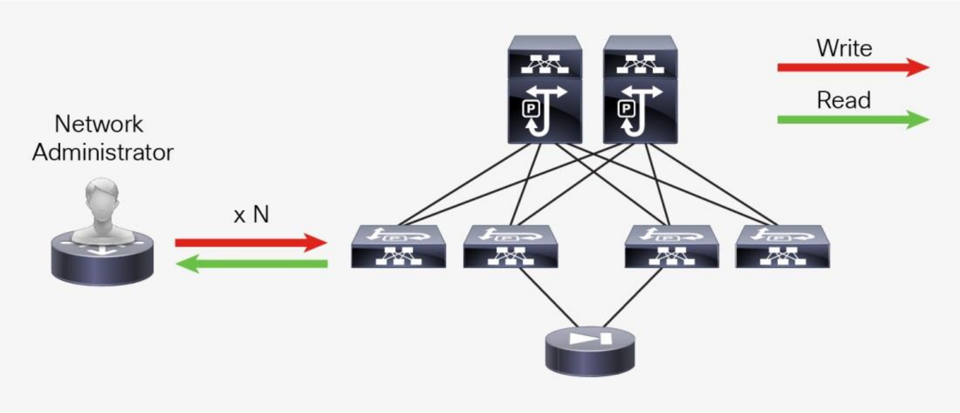
The service graph introduces multiple operational models for deploying L4-L7 services.

The service graph in network policy mode follows a traditional operational model in which the configuration of L4-L7 devices consists of the following steps:

- The network administrator configures the ports and VLANs to connect the firewall or the load balancer.
- The firewall administrator configures the ports and VLANs.
- The firewall administrator configures the ACLs and other components.

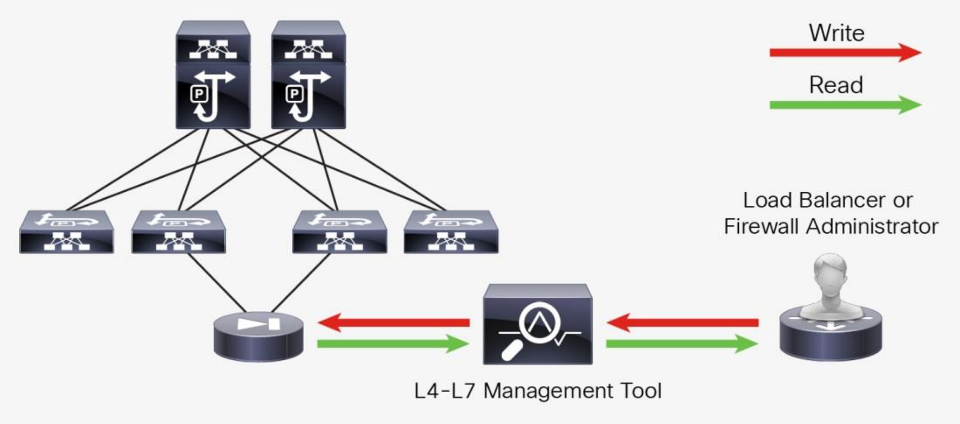
As shown in Figure 8, with the Cisco ACI service graph in network policy mode, the network administrator configures the fabric but not necessarily the firewall.

Figure 8. Cisco ACI Service Graph with the Network Policy Mode Deployment Type: The Network Administrator Manages the Fabric but Not the Firewall or Load Balancer



In addition, with the Cisco ACI service graph in network policy mode, the security administrator administers the firewall through a management tool designed for the L4-L7 device (Figure 9).

Figure 9. With the Network Policy Mode, the Security Administrator Manages the Firewall Directly or Through a Management Tool

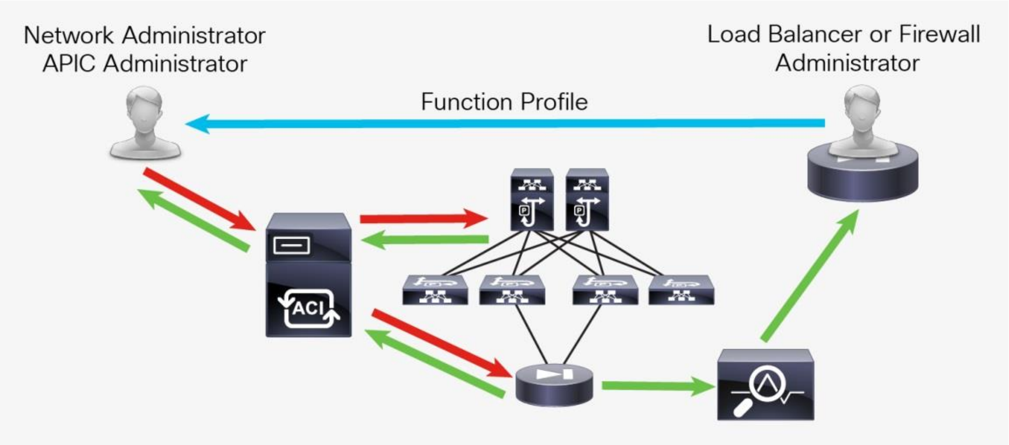


With the Cisco ACI service graph in service policy mode, the management model changes as illustrated in Figure 10.

The network administrator needs to apply the configuration for the network as well as for the firewall through the APIC, and the L4-L7 administrator needs to provide the L4-L7 configuration to the network administrator. This configuration is then assembled as a function profile.

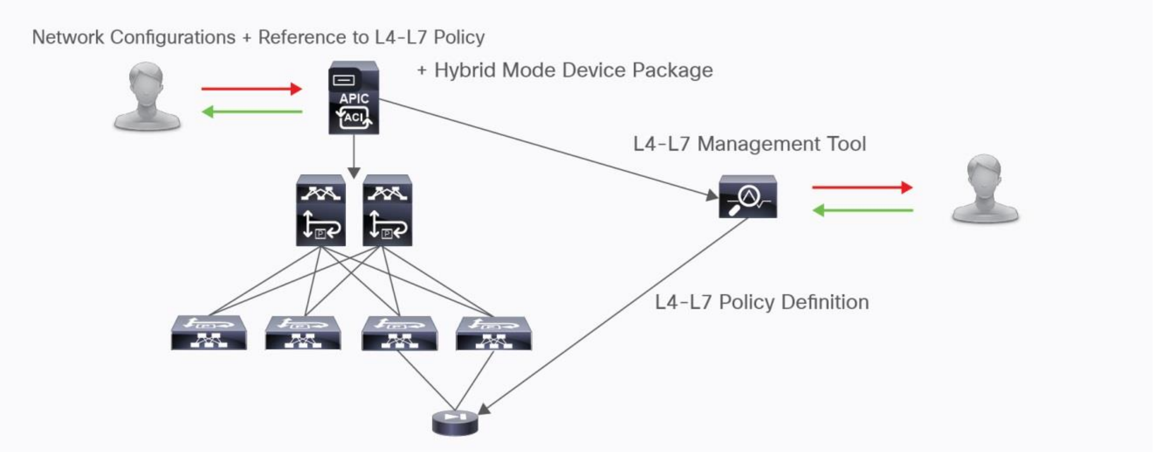
The APIC then programs both the fabric and the L4-L7 device. The L4-L7 administrator can read the configuration from the L4-L7 management tool but cannot make changes to the configuration directly.

Figure 10. Cisco ACI Operational Model with Service Policy Mode: Network and L4-L7 Configuration Are Managed Through APIC



With the Cisco ACI service graph in service manager mode, the L4-L7 administrator defines the L4-L7 configurations through the L4-L7 management tool instead of configuring function profiles with L4-L7 parameters. The APIC administrator configures the service graph and references the L4-L7 policy defined by the L4-L7 administrator. Figure 11 illustrates this concept.

Figure 11. Cisco ACI Operational Model with Service Manager Mode


Network Configurations + Reference to L4-L7 Policy
+ Hybrid Mode Device Package
APIC
ACI
L4-L7 Management Tool
L4-L7 Policy Definition

Design Choices for Bridge Domains, VRF Instances, and EPGs

When deploying a service graph, you can choose among options such as the following:

- Transparent mode: Deploy the L4-L7 device in transparent mode when the L4-L7 device is bridging the two bridge domains. In Cisco ACI, this mode is called go-through mode.

- Routed mode: Deploy the L4-L7 device in routed mode when the L4-L7 device is routing between the two bridge domains. In Cisco ACI, this mode is called go-to mode.
- One-arm mode: Deploy the L4-L7 device in one-arm mode when a load balancer is located on a dedicated bridge domain with one single interface.
- Policy Based Redirect (PBR): Deploy the L4-L7 device on a separate bridge domain than the clients or the servers and redirect traffic to it based on protocol and port number.

Your first design choice is to identify the number of bridge domains and VRF instances that you need and the number of EPGs and contracts.

Bridge Domain and VRF Provisioning

Typically, you need to provision one bridge domain for the outside (or client-side or consumer-side) interface, and one bridge domain for the inside (or server-side or provider-side) interface.

Bridge domains have many configurable options. The main choices that you need to make are whether to enable the following:

- Unknown unicast flooding or hardware proxy
- Address Resolution Protocol (ARP) flooding
- Routing
- Subnet IP address

The next section discusses how to tune these options to optimize flooding.

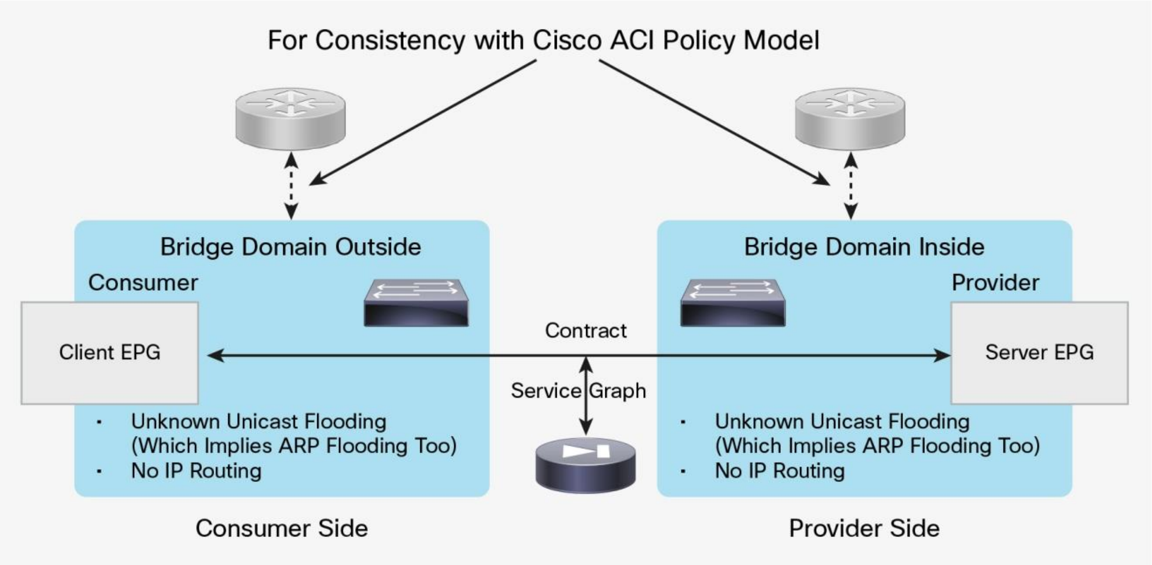
The default configuration, which works for most deployments, sets the parameters as follows:

- Unknown unicast flooding
- ARP flooding
- No routing (except if this bridge domain needs to be the default gateway for the servers or for the L4-L7 device)
- No subnet (except if this bridge domain needs to be the default gateway for the servers or for the L4-L7 device)

Each bridge domain also requires a relationship to a VRF instance. Whether you should allocate one or two VRF instances depends on your design choice.

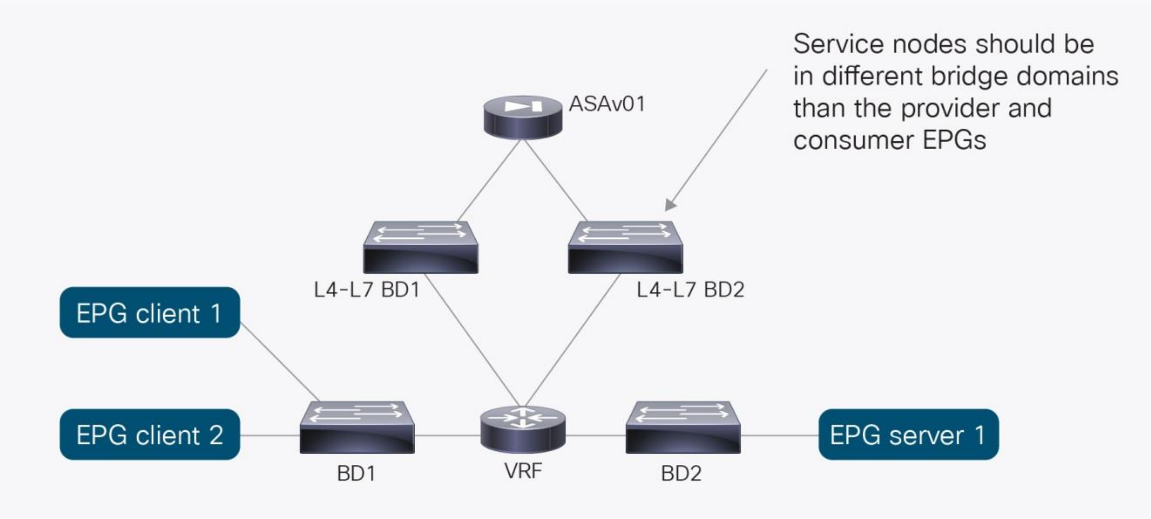
Figure 12 shows a basic setup consisting of two bridge domains with a VRF association. This setup should work for most deployments. This setup uses one EPG for the clients and one EPG for the servers that are associated, respectively, with the outside bridge domain and the inside bridge domain. A VRF instance is allocated to each bridge domain, but it is shown in gray in the figure because it is not really used to route traffic; it is used simply to meet the requirement of the object model for a relationship between a VRF instance and a bridge domain.

Figure 12. Simple Bridge Domain Setup That Works for Most Deployments


For Consistency with Cisco ACI Policy Model
Bridge Domain Outside
Consumer
Client EPG
Unknown Unicast Flooding (Which Implies ARP Flooding Too)
No IP Routing
Contract
Service Graph
Bridge Domain Inside
Provider
Server EPG
Unknown Unicast Flooding (Which Implies ARP Flooding Too)
No IP Routing
Consumer Side
Provider Side

If you deploy the graph with service graph redirect, you need to define one or two bridge domains to which the L4-L7 device connects. These bridge domains are not used to connect the endpoints. Figure 13 shows a design example with service graph redirect. The bridge domains used to connect the L4-L7 device are configured differently from the others because they need to have data-plane learning disabled and Gratuitous ARP (GARP) detection enabled.

Figure 13. Bridge Domain Setup for Service Graph with Policy Based Redirect (PBR)


Service nodes should be in different bridge domains than the provider and consumer EPGs
ASAv01
L4-L7 BD1
L4-L7 BD2
EPG client 1
EPG client 2
BD1
VRF
BD2
EPG server 1

Layer 2 and Layer 3 Forwarding in Cisco ACI

Cisco ACI forwards traffic by using Virtual Extensible LAN (VXLAN) encapsulation. The way that packets are sent to the VXLAN Tunnel Endpoint (VTEP) at which the destination MAC or IP address is located depends on the bridge domain settings. Cisco ACI can forward traffic based on either the destination MAC address of the packet prior to VXLAN encapsulation or the destination IP address of the packet prior to VXLAN encapsulation.

In Cisco ACI, routed traffic is traffic whose destination MAC address is the router MAC address: that is, the subnet MAC address in the bridge domain. Layer 2, or bridged, traffic is traffic whose destination MAC address is not the router MAC address.

Layer 2 traffic forwarding can be based on the MAC address–to–VTEP mapping learned as a result of flooding along the multicast tree of each bridge domain, or it can be based on the mapping database that discovers endpoints. The first forwarding mechanism is the classic VXLAN forwarding approach. It is enabled by setting the bridge domain to perform unknown unicast flooding. With the second mechanism, the leaf switch discovers new endpoints and populates the mapping database. The MAC address–to–VTEP mapping information is always maintained in the mapping database that is stored in the spine proxy switch. If you want the Layer 2 forwarding to be based on the mapping database, you need to enable the hardware-proxy option.

Routed traffic always is forwarded based on the mapping database. This approach requires a lookup of the IP address–to–VTEP mapping information. The endpoint IP address is learned through the leaf switch. The leaf switch discovers the endpoint IP address from the ARP requests of the endpoint or from the data-plane traffic from an endpoint that is sending traffic to the destination MAC address of the router.

Note: This behavior can be disabled in the bridge domain, but this should be done only for a L4-L7 bridge domain used with service graph redirect.

When routing is configured on the bridge domain, the bridge domain learns the IP addresses of the endpoints regardless of the subnet to which their IP address belongs. You should and can configure the bridge domain to learn only the IP addresses of the endpoints that belong to the subnet defined in the bridge domain as a default gateway. This option is called Limit IP Learning to Subnet or Subnet Check.

In summary, the following configurations enable the use of the mapping database for forwarding:

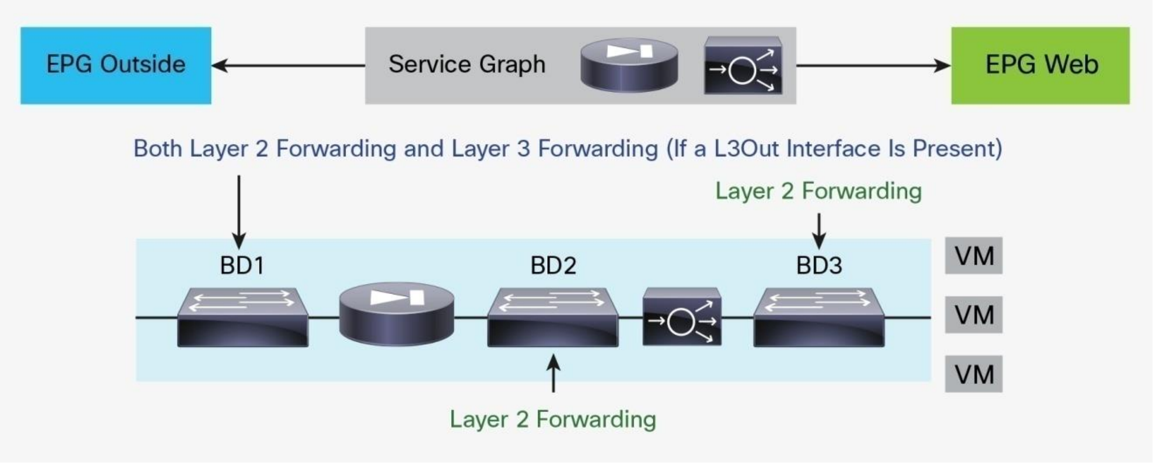
- Hardware-proxy: Enables the use of the MAC address–to–VTEP database for Layer 2 forwarding
- IP routing: Enables the learning of the IP address–to–VTEP mapping and the use of the IP address–to–VTEP database for Layer 3 forwarding

The example in Figure 14 shows where Cisco ACI performs Layer 2 forwarding and where it performs Layer 3 forwarding.

In BD3, the default gateway for the servers is the load balancer; hence, traffic is switched at Layer 2. In BD2, the next hop of the load balancer for outbound traffic is the firewall, and the next hop of the firewall for inbound traffic is the load balancer, so traffic is switched at Layer 2. On BD1, if a subnet is configured in the bridge domain and the default gateway for the firewall is the bridge domain subnet IP address, then traffic is switched at Layer 3.

Note: If Limit IP Learning to Subnet is not enabled on BD1, the mapping database can learn the IP addresses of the endpoints from BD3 as if they were in BD1.

Figure 14. Service Graph Example Showing on Which Bridge Domains Cisco ACI Performs Layer 2 and Layer 3 Forwarding



Bridge Domain Tuning Considerations

You can tune the bridge domain to reduce the amount of flooding in the domain. Two main options are available to reduce flooding:

- Hardware proxy (instead of unknown unicast flooding): This option forwards bridged unknown unicast MAC addresses to the spine-proxy database. This option provides benefits only in the event of bridged traffic. This option has no influence on routed traffic (that is, traffic in which the destination MAC address is the BD MAC address).
- No ARP flooding: This option transforms broadcast ARP requests into unicast packets. For this feature to work, you need to enable IP routing because the mapping database must be populated with the IP addresses of the endpoints. Hardware proxy must be enabled too.

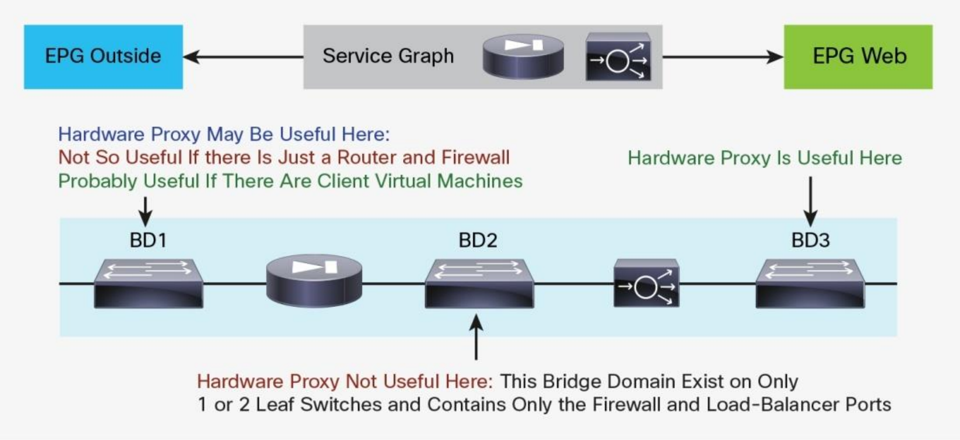
In deciding whether to use these features, consider the following:

- Some L4-L7 devices in transparent (go-through) mode rely on flooding to build the forwarding tables just like a transparent bridge does.
- When a L4-L7 device fails over, the IP address of that device may or may not change the MAC address too. If it does change the MAC address, the Gratuitous ARP (GARP) traffic generated by the L4-L7 device must reach the ARP cache of the adjacent devices. For this to happen, ARP flooding must be enabled (that is, the ARP flooding optimization option must be off).

You can decide whether to use these features to reduce flooding with the L4-L7 device that you are using. However, if you deploy a service graph in go-through mode, Cisco ACI automatically changes the bridge domain settings to enable unknown unicast flooding and ARP flooding. In other words, with go-through mode Cisco ACI doesn’t try to optimize flooding on the bridge domains attached to the L4-L7 device. Therefore, if you use a service graph deployment (managed or unmanaged), you can choose whether to optimize flooding only when you are using the go-to mode.

Assuming a service graph deployment with L4-L7 devices in go-to mode, you also need to consider where flood removal would provide some benefits. Figure 15 illustrates this point. The figure shows a multinode graph. Flooding optimization is useful on BD3 because it has several virtual machines and servers connected to it. The usefulness of flooding optimization on BD1 and BD2 is negligible because BD1 has only the firewall interface and potentially a router interface, and BD2 has only the interfaces of the firewall and the load balancer. Therefore, the only bridge domain for which you may want to optimize flooding is BD3.

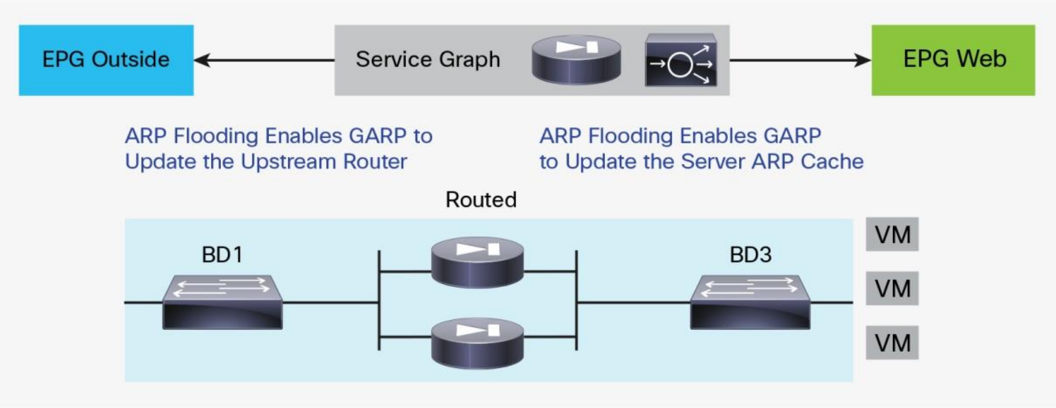
Figure 15. Scenarios in Which Hardware Proxy Provides Benefits


EPG Outside
Service Graph
EPG Web
Hardware Proxy May Be Useful Here:
Not So Useful If there Is Just a Router and Firewall
Probably Useful If There Are Client Virtual Machines
Hardware Proxy Is Useful Here
BD1
BD2
BD3
Hardware Proxy Not Useful Here: This Bridge Domain Exist on Only
1 or 2 Leaf Switches and Contains Only the Firewall and Load-Balancer Ports

You may want to enable hardware proxy on BD3 and maybe on BD1 (if many client virtual machines are connected to BD1), you need to decide whether to optimize unknown unicast MAC address flooding and also ARP flooding.

Figure 16 shows where ARP flooding is needed. With hardware proxy and no ARP flooding, GARP traffic for firewall or load-balancer failover is not flooded. If a service device fails over, the endpoints don’t see the update of the IP address–to–MAC address mapping. This behavior may be acceptable if the L4-L7 device allows you to configure the same MAC address for both L4-L7 devices in the high-availability pair; otherwise, you need to keep ARP flooding enabled.

Figure 16. Tuning ARP Flooding


EPG Outside
Service Graph
EPG Web
ARP Flooding Enables GARP to
Update the Upstream Router
ARP Flooding Enables GARP
to Update the Server ARP Cache
Routed
BD1
BD3
VM
VM
VM

The capability to disable ARP flooding depends on the configuration of hardware proxy and IP routing as follows:

- If hardware proxy is turned off, then ARP flooding is on and cannot be turned off.
- If hardware proxy is turned on but IP routing is turned off, ARP flooding is on and cannot be turned off.
- If hardware proxy is turned on and IP routing is turned on, then you can disable ARP flooding.

You may consider ARP flooding to be necessary because of silent hosts, but this is not completely true. It is true that disabling ARP flooding requires the mapping database to know the endpoint IP address, and for this IP routing must be turned on. But even if the endpoint had been silent, Cisco ACI can resolve the endpoint IP address by sending ARP messages from the subnet IP address of the bridge domain. This feature is called ARP gleaning, and it requires the bridge domain to be configured with a subnet IP address.

In summary, if you want to reduce ARP flooding (you can't completely remove it all the time), you need to configure the bridge domain as follows:

- Hardware proxy must be turned on.
- The ARP flooding option must be disabled.
- IP routing must be turned on.
- The subnet IP address must be configured.
- You should use Limit IP Learning to Subnet (also called Subnet Check)

For most deployments, you should keep ARP flooding on.

Bridge Domain Tuning for Service Graph with Policy Based Redirect (PBR)

When you use service graph redirect, the L4-L7 device is not directly connected to the endpoints. Therefore, the configuration of the bridge domains to which the virtual machines or the physical servers are connected (BD1 and BD2 in Figure 17) can be performed without having to consider the requirements of the L4-L7 device. In most cases, you can use hardware proxy, and in certain cases you can also optimize ARP flooding.

The bridge domain that connects to the L4-L7 device must instead be configured as follows:

- IP routing should be enabled.
- Subnet should be configured.
- GARP-based detection should be on.
- Data-plane learning should be disabled.

Figure 17 shows why data-plane learning must be disabled for the L4-L7 bridge domain.

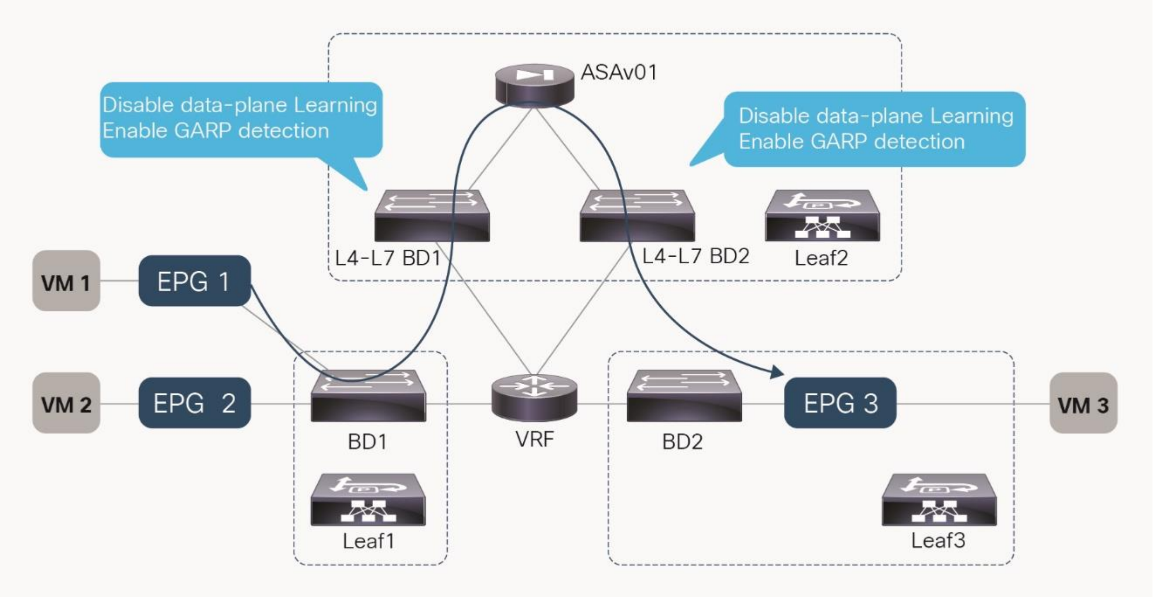
In this example, VM1, EPG1, and BD1 are on Leaf1. The L4-L7 bridge domains and the L4-L7 device are on Leaf2. VM3 is on Leaf3. The redirect policy configured by the APIC administrator says that traffic from EPG1 to EPG3 must go to the firewall.

The mapping database learns that VM1 is on Leaf1 and that VM3 is on Leaf3 as a result of ARP gleaning or because VM1 and VM3 sent some routed traffic.

VM1 sends traffic to VM3. Cisco ACI redirects this traffic to the firewall. The firewall routes the traffic to L4-L7 BD2. If L4-L7 BD2 was configured like a regular bridge domain, it would learn the location of endpoints from routed traffic. In this example, the source IP address of the traffic entering L4-L7 BD2 is the IP address of VM1, and the traffic is routed. Hence, Cisco ACI would normally update the mapping database to report that VM1 is on Leaf2 instead of Leaf 1. This would be incorrect.

If data-plane learning is disabled on the L4-L7 bridge domain, the traffic forwarded by the firewall doesn't modify the mapping database.

Figure 17. Bridge Domain Configuration for Service Graph Redirect.



IP Routing Considerations

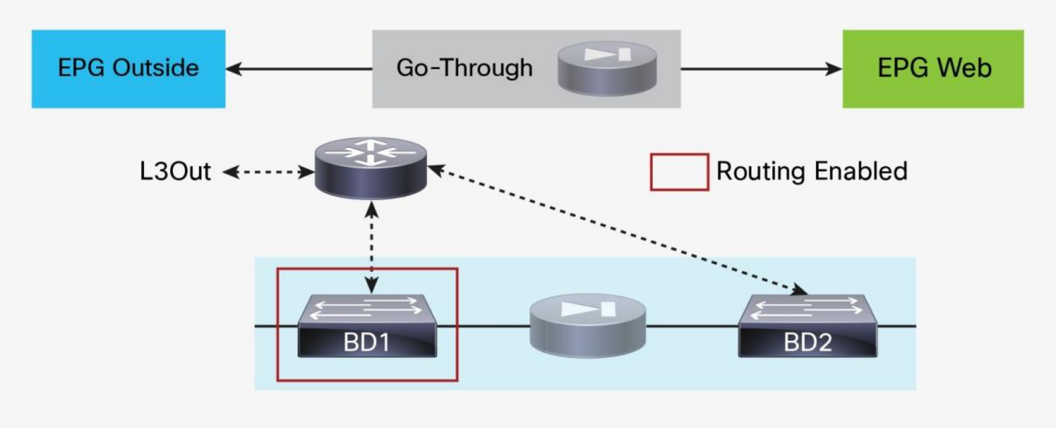
You may need to enable routing on a bridge domain for two main reasons:

- Because you want Cisco ACI to route traffic
- Because you want the mapping database to hold the IP address information of the endpoints for features such as dynamic endpoint attach or for troubleshooting purposes

Note: Dynamic Endpoint Attach is a feature that allows Firewall ACLs or ADC load balanced servers to be dynamically configured when new endpoints are attached to an EPG.

Figure 18 illustrates a service graph with a firewall deployed in go-through mode, with BD1 providing routing to the outside. To implement this design, you need to enable routing on BD1. In this design, the mapping database learns the IP addresses of the endpoints attached to BD2 as if they were in BD1. The MAC addresses of the endpoints that are in BD2 are learned on both BD1 and BD2.

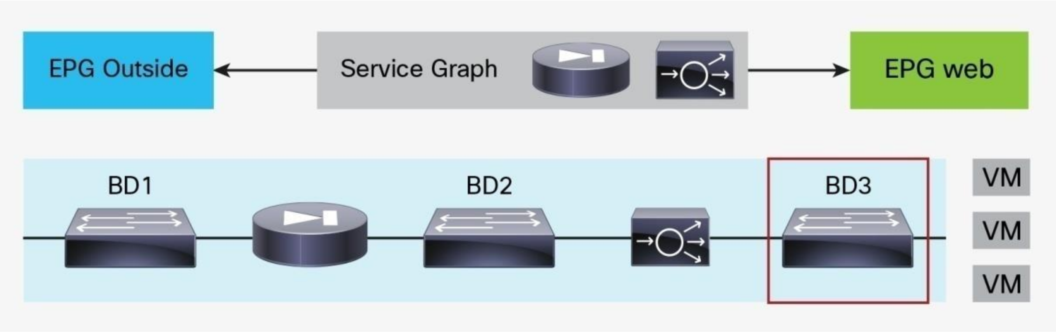
Figure 18. Enabling Routing on a Bridge Domain to Route the Traffic to the Outside



You also may want to enable routing on the bridge domain to which the servers are attached. You may want to do this not because you want the bridge domain to be the default gateway, but because the mapping database needs to learn the IP addresses of the servers. Figure 19 illustrates this use case.

The mapping database in BD3 learns the endpoint IP addresses from the ARP requests originated by the hosts. No data-plane learning of the host IP addresses happens because the traffic is destined for the MAC address of the load balancer.

Figure 19. Enabling Routing on the Server-Side Bridge Domain to Use Endpoint Attachment

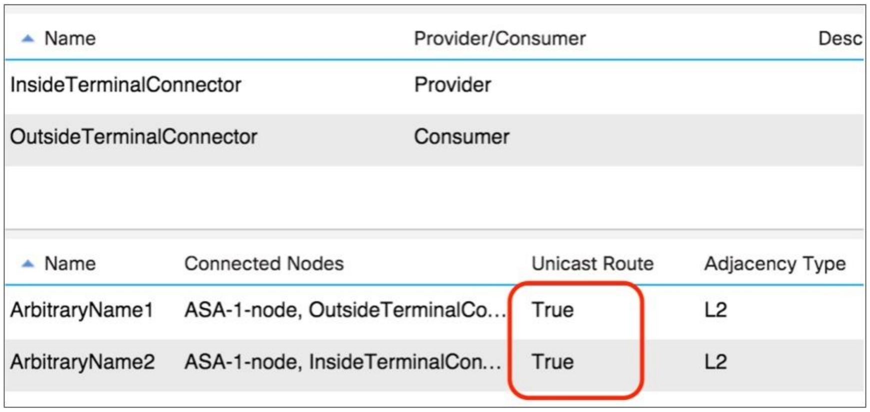


When enabling routing, keep in mind that you must enable it in two places in the service graph:

- The bridge domain
- The graph connector

Figure 20 illustrates this point.

Figure 20. When Enabling Routing on a Bridge Domain, Make Sure That the Graph Template Connectors Are Set for Routing



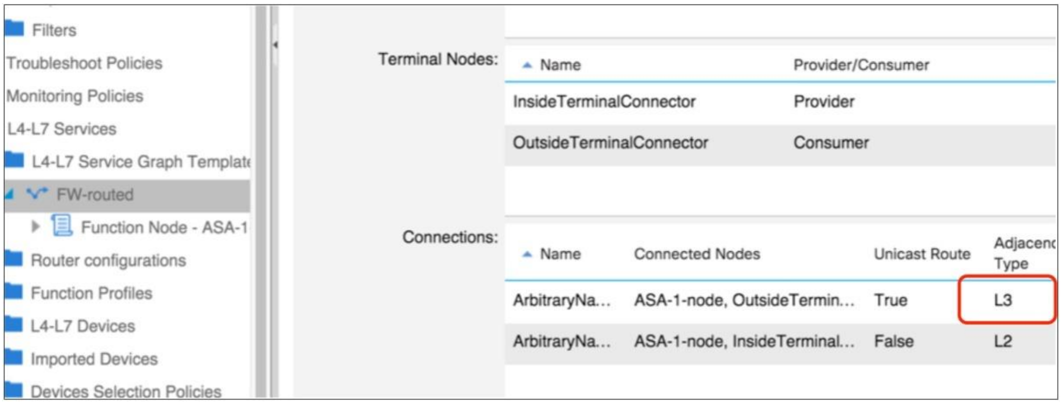
Name	Provider/Consumer	Desc
InsideTerminalConnector	Provider	
OutsideTerminalConnector	Consumer	

Name	Connected Nodes	Unicast Route	Adjacency Type
ArbitraryName1	ASA-1-node, OutsideTerminalCo…	True	L2
ArbitraryName2	ASA-1-node, InsideTerminalCon…	True	L2

In general, these connectors are set to unicast routing by default. This setting makes the final state of the bridge domain dependent only on the routing configuration on the bridge domain.

If the connector is associated with a bridge domain that provides the Layer 3 outside (L3Out) interface function, in addition to verifying that the unicast routing option is set to true, you need to make sure that the adjacency is set to Layer 3, not Layer 2, as in Figure 21.

Figure 21. To Help Ensure That the Switch Virtual Interface Is Enabled on the Bridge Domain with L3Out, Set Adjacency to Layer 3



Terminal Nodes:

Name	Provider/Consumer
InsideTerminalConnector	Provider
OutsideTerminalConnector	Consumer

Connections:

Name	Connected Nodes	Unicast Route	Adjacenc Type
ArbitraryNa…	ASA-1-node, OutsideTermin…	True	L3
ArbitraryNa…	ASA-1-node, InsideTerminal…	False	L2

In summary, IP routing may be necessary in bridge domains that meet the following criteria:

- Bridge domains that provide routing to bridge domains that provide routing to another bridge domain or to the outside
- Bridge domains to which servers are connected, if you plan to use endpoint attachment

VRF Design Considerations for Go-To and Go-Through Mode Deployments

In Cisco ACI, every bridge domain must have a relationship to a VRF instance. The question is whether the same VRF instance can be used for multiple bridge domains, or whether each bridge domain should use a different VRF instance, as illustrated in Figure 22.

As the upper portion of the figure shows, you may have a service graph with two bridge domains associated with the same VRF instance. Alternatively, you may need two separate VRF instances, one for each bridge domain, as in the bottom portion of the figure. The figure shows the VRF instances in gray because they are configured only to meet the object tree requirement to have a VRF instance associated with a bridge domain. However, no bridge domain in this figure is used to route the traffic, so the VRF instance is not doing much from the perspective of the data plane.

Figure 22. The Bridge Domain Requires a Relationship with a VRF Instance, and in Some Designs You May Need to Allocate One VRF Instance per Bridge Domain

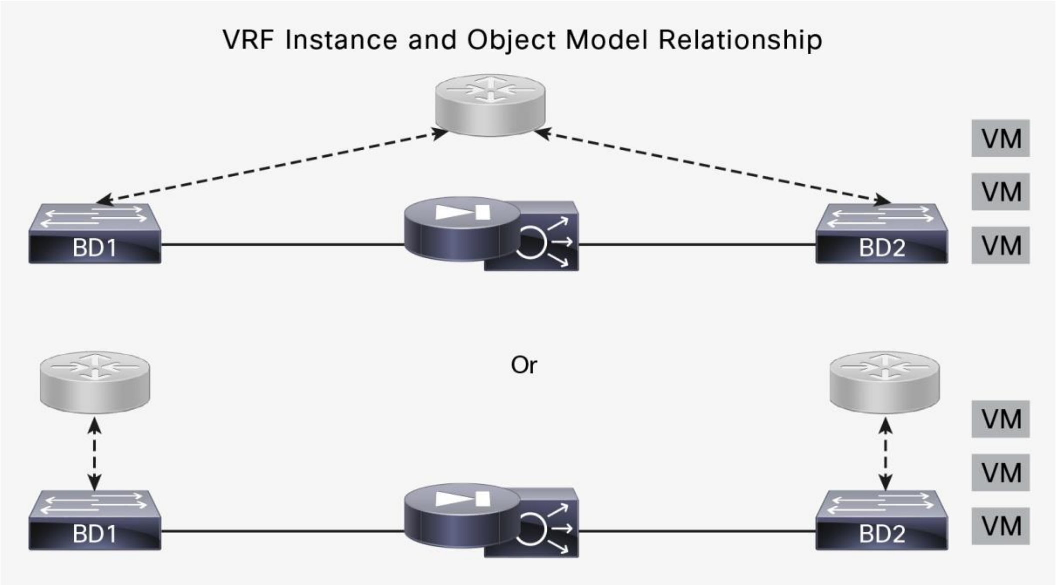
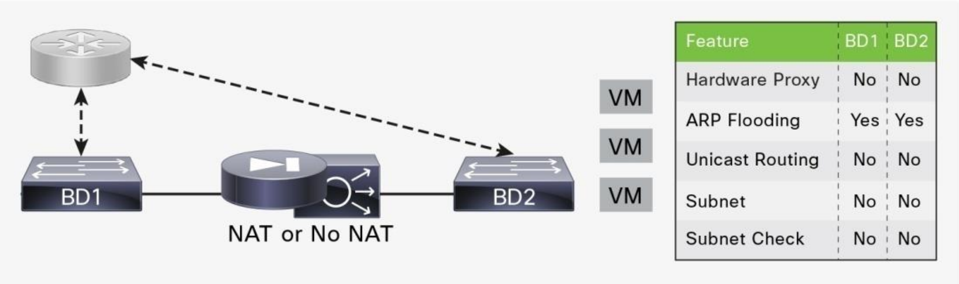


Figure 23 shows a simple design in which a single VRF instance is sufficient, and the instance does not need to be split because IP routing is not enabled for either BD1 or BD2. With this design, the mapping database is just learning MAC addresses in both bridge domains; hence, traffic entering from BD1 cannot reach BD2 by bypassing the L4-L7 device. No NAT configuration is required on the L4-L7 device.

Figure 23. Design Using Bridge Domains Without Routing

(**Note:** The VRF instance is shown in gray to indicate that this relationship is needed just to meet object tree requirements.)



Feature	BD1	BD2
Hardware Proxy	No	No
ARP Flooding	Yes	Yes
Unicast Routing	No	No
Subnet	No	No
Subnet Check	No	No

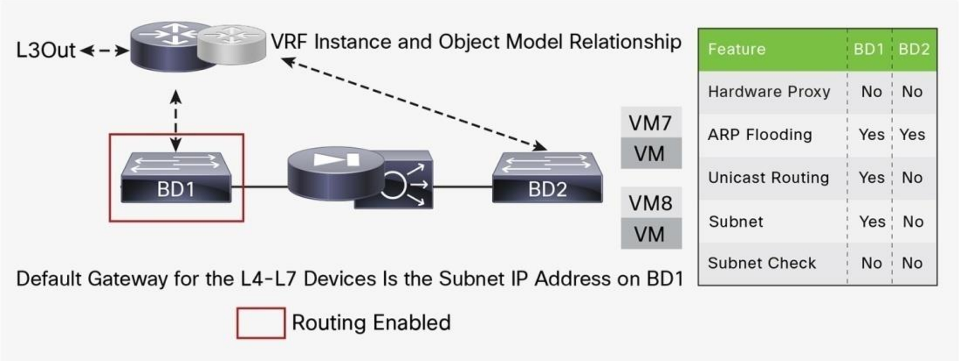
Figure 24 shows another design that doesn't require two VRF instances. In this case, routing is enabled on BD1 only (hence, the VRF instance is shown in color for the relationship with BD1 and in gray for the relationship with BD2).

There are two possible scenarios to make this design work:

- Subnet check is not enabled on BD1: The endpoint IP addresses of the hosts from BD2 are learned on BD1 and associated with the L4-L7 device's MAC address. In this design, the IP addresses of VM7 and VM8 are learned on BD1 with the MAC address of the firewall or the load balancer. The traffic therefore can be routed to VM7 and VM8 from an L3Out interface. However, this design is not recommended. If you were to enable IP routing on BD2, the mapping database would be confused because the same IP address could appear on both BD1 and BD2.
- Subnet check is enabled, but the L4-L7 device uses NAT: If subnet check is enabled on BD1, the VM7 and VM8 IP addresses are not learned in BD1 (which is desirable). To make sure that the servers are reachable, the L4-L7 device must apply NAT to them so that BD1 learns the NAT addresses of VM7 and VM8. With this design, you can also enable IP routing on BD2, and because of the use of NAT on the L4-L7 device and the subnet check on BD1, the VM7 and VM8 endpoint IP addresses will be learned only in BD2.

Figure 24. Design with Routing Enabled on Bridge Domain with L4-L7 Device in Go-To Mode

(**Note:** This design is for explanation purposes only; this is not a design recommendation. Also, the part of the VRF instance associated with BD2 is shown in gray to indicate that this relationship is needed just to meet object tree requirements.)


L3Out
VRF Instance and Object Model Relationship
BD1
BD2
VM7
VM
VM8
VM
Default Gateway for the L4-L7 Devices Is the Subnet IP Address on BD1
Routing Enabled

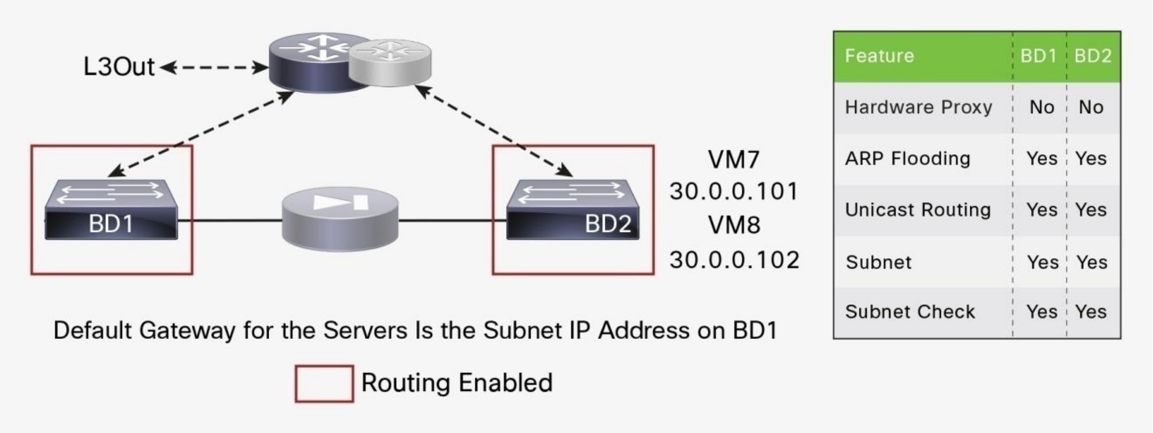
Feature	BD1	BD2
Hardware Proxy	No	No
ARP Flooding	Yes	Yes
Unicast Routing	Yes	No
Subnet	Yes	No
Subnet Check	No	No

Now imagine a different scenario in which you deploy a transparent device with two bridge domains that are both enabled for routing. This scenario is just theoretical because the service graph wizard will not let you apply a go-through graph template to two bridge domains that are both enabled for routing; however, you could potentially design a service insertion topology like this one if you were not using the service graph feature.

Figure 25 shows BD1 and BD2 both configured for routing. The servers' default gateway is on BD1; hence, the part of the VRF instance associated with BD1 is shown in color. The subnet IP address on BD2 will not be used by the servers as their default gateway; hence, the part of the VRF instance associated with BD2 is shown in gray.

Figure 25. If Routing is Enabled in Both Bridge Domains, in Some Scenarios like the One in This Picture, the VRF Instance Will Need to Be Split.

(**Note:** The design in this figure is not recommended; it is provided only as an example to explain the use of a split VRF instance. Also, the part of the VRF instance associated with BD2 is shown in gray to indicate that this relationship is needed just to meet object tree requirements.)


L3Out
BD1
BD2
VM7
30.0.0.101
VM8
30.0.0.102
Default Gateway for the Servers Is the Subnet IP Address on BD1
Routing Enabled

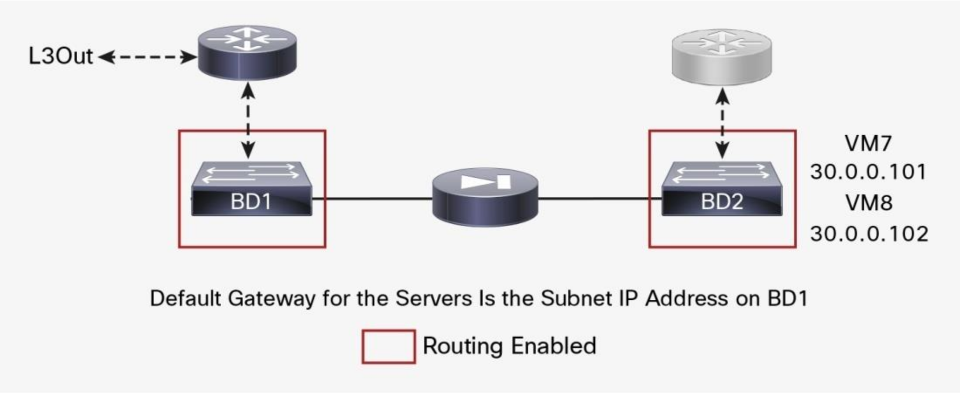
Feature	BD1	BD2
Hardware Proxy	No	No
ARP Flooding	Yes	Yes
Unicast Routing	Yes	Yes
Subnet	Yes	Yes
Subnet Check	Yes	Yes

Assuming that you could deploy such a service graph as shown in the preceding example, the mapping database would be confused, because the same endpoint would appear in two bridge domains for the same VRF instance. In the example in Figure 25, the IP address of VM7 and VM8 would be learned on BD1 and BD2: the routing decision may try to forward traffic directly to BD2, while the service graph contracts would prevent this direct path. For this reason, if you try to deploy a go-through service graph with two bridge domains configured for routing, you will receive a fault message, and the graph will not be deployed.

The theoretical solution, provided for educational purposes only, is to split the VRF instance so that each bridge domain has its own address space, as shown in Figure 26.

Figure 26. In This Theoretical Design, with a Go-Through Device Placed Between Two Bridge Domains That Have Routing Enabled, You Would Have to Create Two Separate VRF Instances to Avoid Confusing the Mapping Database

(**Note:** This is not a design recommendation. Also, the VRF instance associated with BD2 is shown in gray to indicate that this relationship is needed just to meet object tree requirements.)


L3Out
BD1
BD2
VM7
30.0.0.101
VM8
30.0.0.102
Default Gateway for the Servers Is the Subnet IP Address on BD1
🟥 Routing Enabled

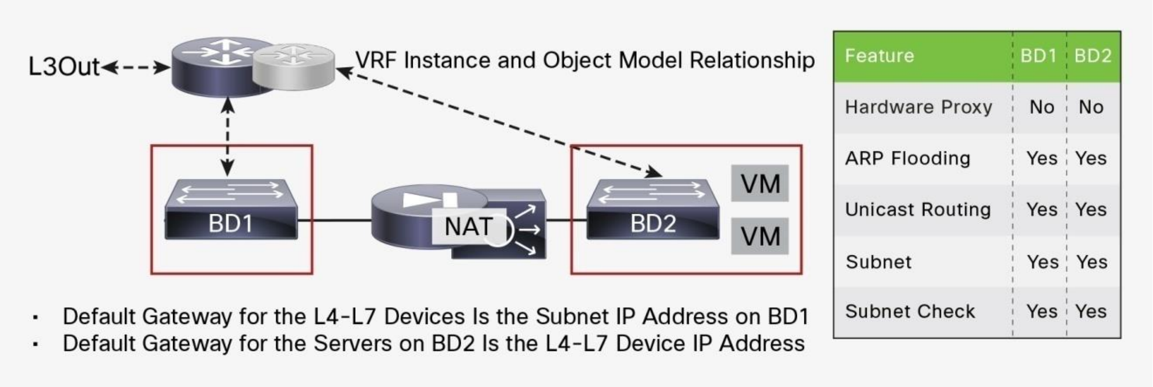
For this design to work (assuming that the service graph would let you deploy it), you need the following configuration:

- Because the subnet is identical on both bridge domains, you need to provide a different subnet IP address on both bridge domains and change the default MAC address so that the addresses don't conflict.
- Configure subnet check, even though subnet check will not make much difference because the 30.0.0.x network will exist in both bridge domains.
- Define the contracts scope as tenant or global instead of VRF instance.

Figure 27 shows a valid design in which IP routing is enabled on both bridge domains. The L4-L7 device is configured for Network Address Translation (NAT). There is no need to use two separate VRFs because even if a device were trying to send traffic to the original address of an endpoint in BD2, the service graph contracts would prevent it.

Figure 27. Design with L4-L7 Device Performing NAT and IP Routing Enabled on Both Bridge Domains; Only One VRF Instance Is Needed for Both Bridge Domains

(**Note:** The part of the VRF instance associated with BD2 is displayed in gray to indicate that this relationship is needed just to meet object tree requirements.)


L3Out
VRF Instance and Object Model Relationship
BD1
NAT
BD2
VM
VM
Default Gateway for the L4-L7 Devices Is the Subnet IP Address on BD1
Default Gateway for the Servers on BD2 Is the L4-L7 Device IP Address

Feature	BD1	BD2
Hardware Proxy	No	No
ARP Flooding	Yes	Yes
Unicast Routing	Yes	Yes
Subnet	Yes	Yes
Subnet Check	Yes	Yes

In all the designs in which IP routing is enabled on the bridge domain connected to the L4-L7 device as with BD1, Cisco ACI learns the IP address of the endpoints of BD2 associated with the L4-L7 device MAC address on BD1. Two important considerations apply:

- Maximum number of IP addresses per MAC address that are supported: At the time of this writing, Cisco ACI supports a maximum of 1024 IP addresses associated with the same MAC address, so you need to make sure that, with or without NAT, the maximum number of IP addresses learned on BD1 from the L4-L7 device interface stays within this limit.
- Capability for Cisco ACI to age the individual IP addresses: If Cisco ACI learns multiple IP addresses for the same MAC address as in the case of BD1, they are considered to refer to the same endpoint. To help ensure that Cisco ACI ages out each NAT IP address individually, you need to enable an option called IP Aging under Fabric > Access Policies > Global Policies > IP Aging Policy.

In summary, when using designs that require interconnection of multiple bridge domains with IP routing enabled, you should follow these guidelines:

- Enable Limit IP Learning to Subnet to avoid learning the endpoint IP addresses of other bridge domains.
- When using a L4-L7 go-through design, do not enable routing on both the bridge domains that the transparent L4-L7 device connects.
- When deploying a L4-L7 device in go-to mode, you can enable routing on both bridge domains if you perform NAT on the L4-L7 device. With this type of deployment, you should also configure IP Aging Policy to age the NAT IP addresses individually.

Using L3Out for Routing to the L4-L7 Device

If you don't use NAT on the L4-L7 device and you want to send traffic whose destination IP address is the endpoint IP address through a firewall or a load balancer, you can use service graph redirect or you need to configure dynamic or static routing to the L4-L7 device through a L3Out connection.

Cisco ACI doesn't let you configure routing on the bridge domain directly. The building block for dynamic and static routing configurations is L3Out.

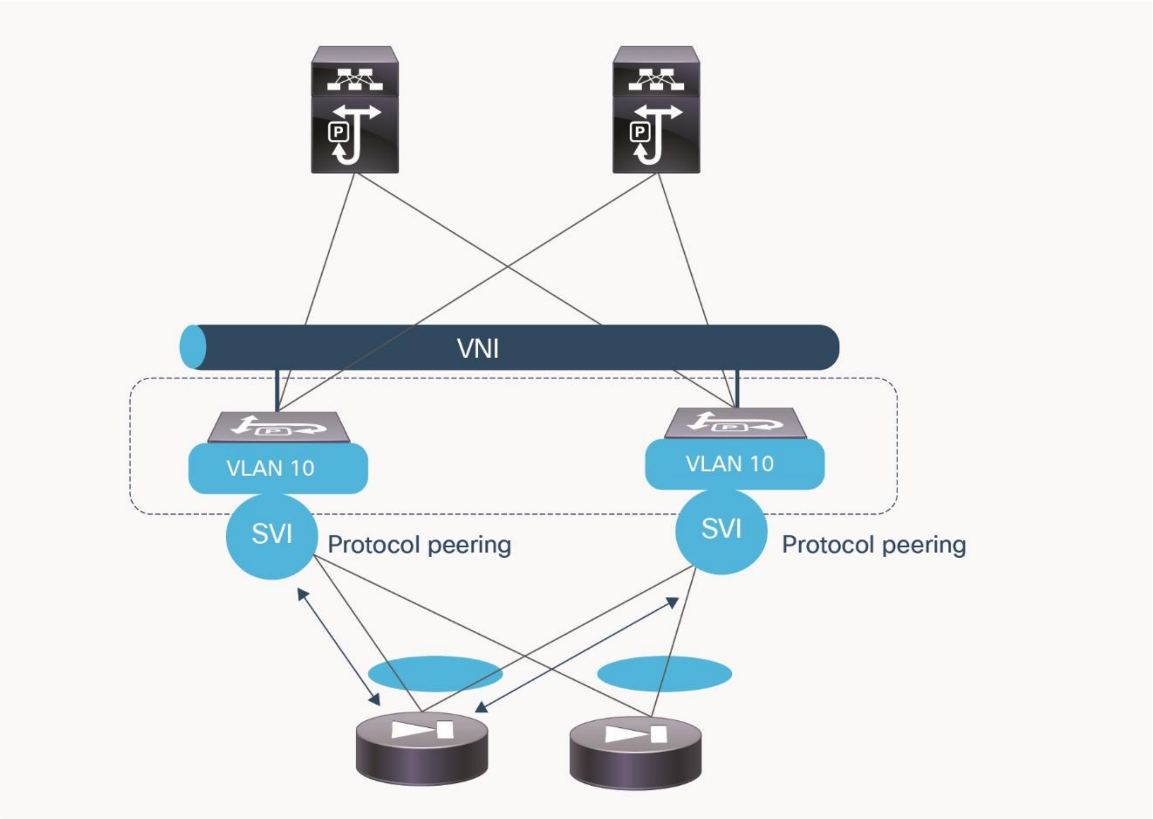
An L3Out policy is used to configure the interfaces, protocols, and protocol parameters necessary to provide IP connectivity to external routing devices. An L3Out connection is always associated with a VRF instance. L3Out connections are configured using the External Routed Networks option on the Networking menu for a tenant.

Part of the L3Out configuration also involves defining an external network (also known as an external EPG) for the purpose of access list filtering. The external network is used to define the subnets that are potentially accessible through the Layer 3 routed connection.

When using L3Out to route to the L4-L7 device, you normally define a L3Out connection based on the Switch Virtual Interfaces (SVIs) to which the L4-L7 device connects. For this you need to define multiple logical interface profiles with the same encapsulation. The logical interface profiles are the path to the L4-L7 device interface. The path can also consist of a virtual Port Channel (vPC). Using the same encapsulation, you are creating an external bridge domain that switches traffic between the L3Out connection and the L4-L7 device. You are also helping ensure Layer 2 adjacency between active-standby L4-L7 devices connected to the same L3Out connection with the same encapsulation.

Static and dynamic routing both work on the L3Out SVI with vPC. If you are using static routing, you would also define a secondary IP address as part of the SVI and vPC configuration. The secondary IP address would be used in the L4-L7 static routing configuration as the next hop (Figure 28).

Figure 28. Design with L3Out to the L4-L7 Device with SVIs and vPC



The Layer 3 external or external network defined in the L3Out connection is equivalent to an EPG, so you use this to connect the service graph.

Depending on the hardware used for the leaf nodes and on the software release, using more than two leaf nodes as part of the same L3Out connection in Cisco ACI may have restrictions. Restrictions apply if:

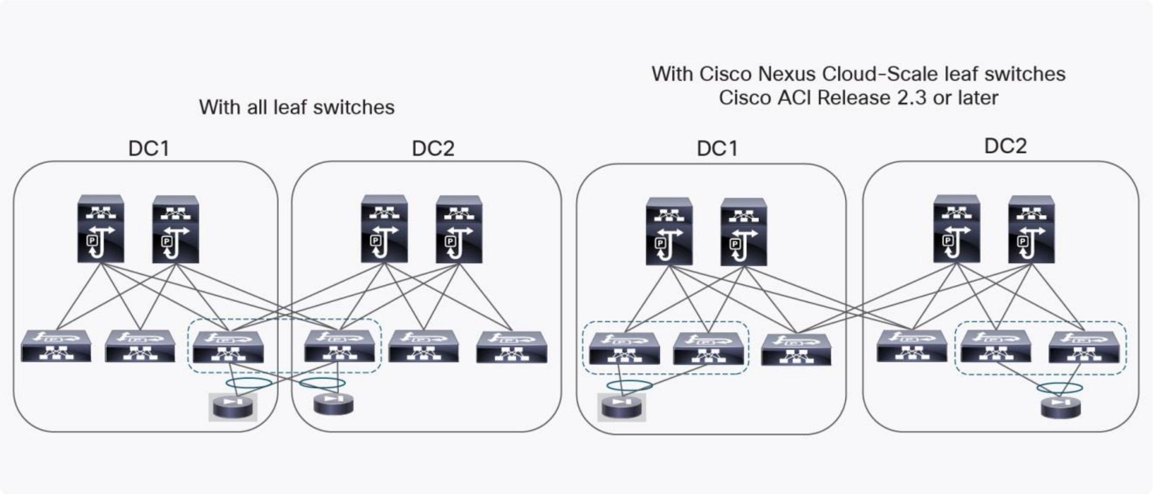
- The L3Out connection consists of more than two leaf nodes with the SVI in the same encapsulation (VLAN)
- The border leaf nodes are configured with static routing to the external device
- The connectivity from the outside device to the fabric is vPC based

These restrictions arise because traffic may be routed to a L3Out connection and then bridged on the external bridge domain to another L3Out connection.

The left side of Figure 29 shows a topology that works with both first- and second-generation leaf switches. The right side shows a topology that works with only Cisco Nexus® 9300 EX and FX platform switches. In the topology, Cisco ACI is configured for static routing to an external active-standby firewall pair. The L3Out connection uses the same encapsulation on all the border leaf nodes to allow static routing from any border leaf to the active firewall. The dotted line highlights the border leaf nodes.

Note: First generation Cisco ACI leaf switches are the Cisco Nexus 9332PQ, 9372PX-E, 9372TX-E, 9372PX, 9372TX, 9396PX, 9396TX, 93120TX, and Cisco Nexus 93128TX Switches.

Figure 29. Design Considerations with Static Routing L3Out with SVI and vPC

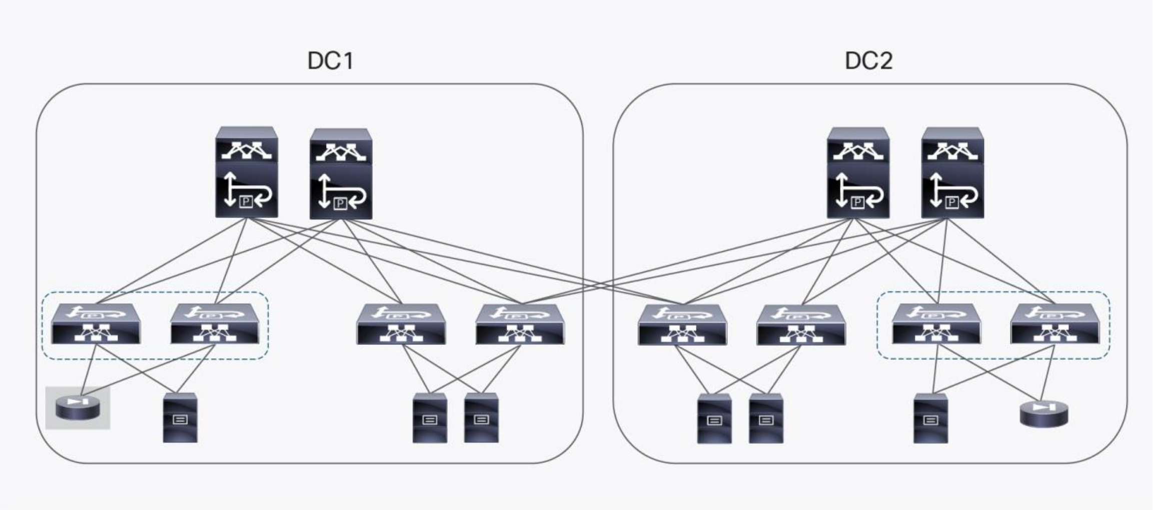

With all leaf switches
DC1
DC2
With Cisco Nexus Cloud-Scale leaf switches
Cisco ACI Release 2.3 or later
DC1
DC2

With topologies consisting of more than two first-generation border leaf switches, the preferred approach is to use dynamic routing and a different VLAN encapsulation per vPC pair on the L3Out SVI. This approach is preferred because the fabric can route the traffic to the L3Out connection that has reachability to the external prefix without the need to perform bridging on an outside bridge domain.

Regardless of which hardware is used on the leaf configured for L3Out, if you are using first-generation leaf switches in the fabric, you also need to consider whether there are servers connected to the same leaf configured for L3Out to an L4-L7 device (Figure 30).

The recommendations related to this design take into account the policy Content Addressable Memory (CAM) filtering optimization called ingress filtering, which is controlled by the configurable option Policy Control Enforcement Direction in the VRF configuration. See https://www.cisco.com/c/en/us/solutions/collateral/data-center-virtualization/application-centric-infrastructure/white-paper-c11-737909.html#_Toc478773999.

Figure 30. Design Considerations When Attaching Endpoints to Leaf Nodes Configured with L3Out



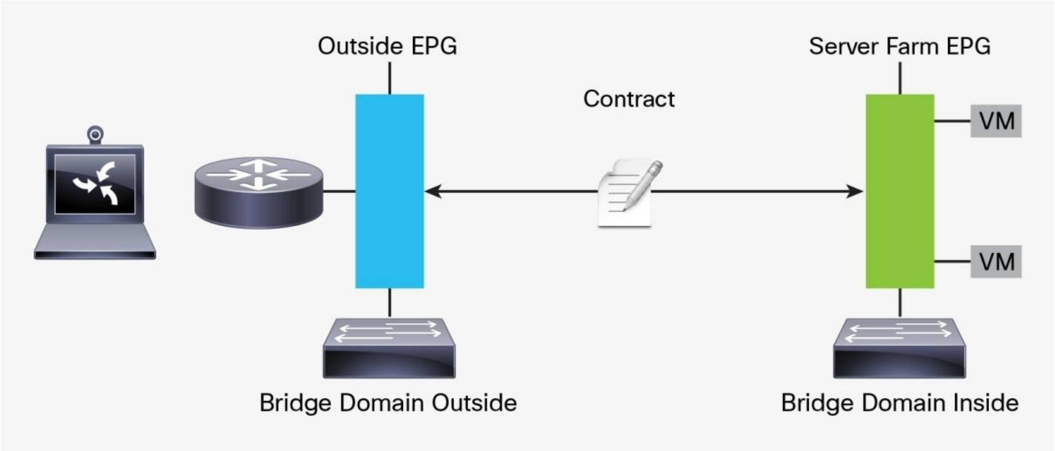
The following considerations apply to this design:

- Attaching endpoints to border leaf switches is fully supported when the leaf switches are all Cisco Nexus 9300 EX and FX platform switches. You should use Cisco ACI Release 2.2(2e) and you should configure Fabric > Access Policies > Global Policies > Fabric Wide Setting Policy by selecting Disable Remote EP Learn.
- If the computing leaf switches, that is, the leaf switches to which the servers are connected, are first-generation leaf switches, you need to consider the following options:
    - If VRF ingress policy is enabled (the default and recommended setting), you need to verify that the software is Cisco ACI Release 2.2(2e) or later. You also should configure the option to disable endpoint learning on the border leaf switches. You can disable remote IP address endpoint learning on the border leaf switch from Fabric > Access Policies > Global Policies > Fabric Wide Setting Policy by selecting Disable Remote EP Learn.
    - You can also configure the VRF instance for egress policy by selecting the Policy Control Enforcement Direction option Egress under Tenants > Networking > VRFs.

EPGs, Contracts, and Connectors

As previously mentioned, the service graph is not attached directly to two bridge domains, but it is associated with a contract that is established between two EPGs, with each EPG is associated with a bridge domain. The example in Figure 31 shows that the service graph is not attached directly to bridge domains but through EPGs.

Figure 31. The Service Graph Is Inserted Between Bridge Domains by Associating It with EPGs



Device Selection Policy

When you define a graph template, you define the device type or the sequence of devices that should be placed between the consumer and the provider EPGs.

The graph template abstraction includes the definition of connectors for the graph nodes: that is, for the L4-L7 devices.

In most deployments, for instance, if a firewall is deployed in go-to mode between two bridge domains (such as bridge domain outside and bridge domain inside), the bridge domain to which the service graph node connector should attach is the bridge domain that is associated with the EPG to which the graph itself connects.

In other deployment designs, such as when the device is deployed in one-arm mode or with redirect, the connector is attached to a different bridge domain than the one in which the provider and consumer connectors are located. The bridge domain to which the service graph is attached can be specified by navigating to Devices Selection Policies > Logical Device Context.

This configuration also tells Cisco ACI where to deploy the shadow EPG.

Graph Connector Properties

The connector also has two properties: it can be Layer 3 or Layer 2, and you can choose to enable or disable unicast routing on the bridge domain to which it connects.

You can find the connector configuration under Tenant > L4-L7 Services > L4-L7 Service Graph Templates by selecting a template and then selecting the Policy tab, under Connections.

In most cases, the connector should be set to Layer 2 unless you need to bring up the pervasive SVI on a bridge domain that has no endpoints.

If the connector is set for unicast routing, the bridge domain forwarding depends on whether unicast routing is enabled or disabled on the bridge domain itself. If the connector is set to not use unicast routing, then the bridge domain will not perform routing even if the bridge domain is configured for routing.

If you are using the routed mode with an L3Out interface instance, the connector to the outside bridge domain must be configured as Layer 3. You can configure this connector through the GUI by selecting CON1 and changing Adjacency Type from L2 to L3.

You can set the adjacency type through REST calls as follows:

```
<vnsAbsConnection name = "CON1" adjType=L3>
 <vnsRsAbsConnectionConns tDn="uni/tn-Sales/AbsGraph-WebGraph/AbsTermNodeCon-
Consumer/AbsTConn" />
  <vnsRsAbsConnectionConns tDn="uni/tn-Sales/AbsGraph-WebGraph/AbsNode-Virtual-
Server/AbsFConn-external" />
</vnsAbsConnection>
```

Deploying the Graph Template on Multiple EPG Pairs

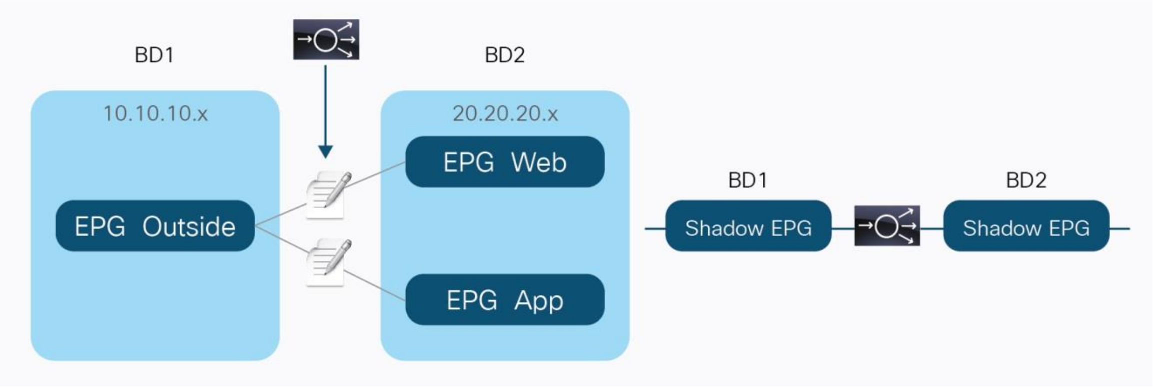
The service graph is always associated with a contract between two EPGs.

A L4-L7 device can be connected through a service graph to multiple EPGs. Because the interfaces of the L4-L7 devices are the same, Cisco ACI allocates a different VLAN for the L4-L7 interface and the associated shadow EPG each time the consumer-side or provider-side EPG is in a different bridge domain.

Figure 32 illustrates this point. In this figure, the graph template is applied one time between the EPG outside and the EPG web interfaces, and it is applied a second time between the EPG outside and EPG appliance interfaces. The EPG web and EPG appliance interfaces are in the same bridge domain; hence, the L4-L7 appliance interfaces are associated with two shadow EPGs: one for BD1 and one for BD2.

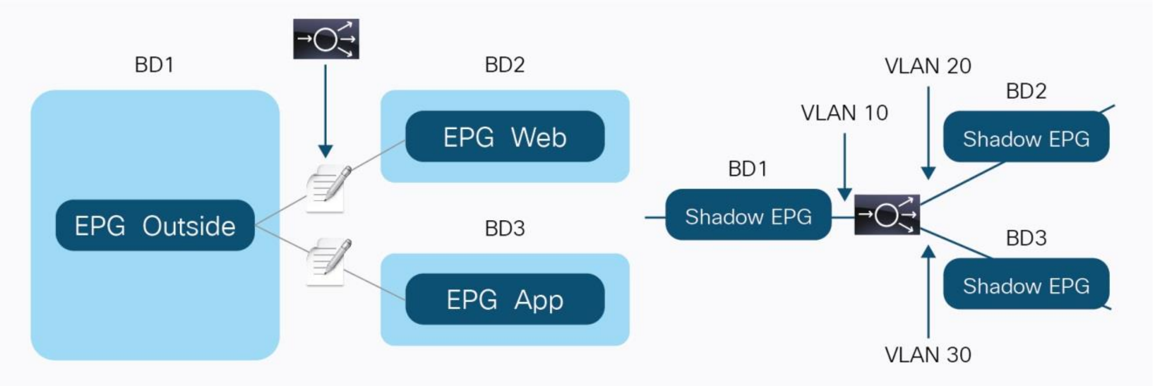
Even if the graph template is applied to more EPGs in BD1 or BD2, the L4-L7 appliance is still connected only to the two shadow EPGs.

Figure 32. When the Service Graph Is Used Between Multiple EPGs on Two Bridge Domains, the L4-L7 Appliance Always Is Attached to Two Shadow EPGs



If the graph template is applied to EPGs in different bridge domains, Cisco ACI will configure more shadow EPGs (one per bridge domain), as shown in Figure 33. In this example, the L4-L7 appliance has the server-side NIC configured to trunk multiple VLANs (VLAN 20 for the shadow EPG in BD2, and VLAN 30 for the shadow EPG in BD3). With a L4-L7 deployment with a device package, Cisco ACI assigns the VLAN to the L4-L7 device interface and to the shadow EPGs, making sure that they match.

Figure 33. When the Service Graph Is Used Between Multiple EPGs in Three Bridge Domains, the L4-L7 Appliance Is Attached to Three Shadow EPGs, and the NICs on the Appliance Trunk Multiple VLANs



You can also change the device selection policies (logical device contexts) to select a different NIC for each EPG to which that the graph template is applied.

Assume that you had defined these logical interfaces:

```
<vnsLDevVip name="ASAv01-cluster">
     <vnsCDev name="ASAv01-active" vmName="ASAv01" vcenterName="line1" >
     <vnsCIf name="Gig0/0" vnicName="Network adapter 2"/>
     <vnsCIf name="Gig0/1" vnicName="Network adapter 3"/>
     <vnsCIf name="Gig0/2" vnicName="Network adapter 4"/>
</vnsCDev>
<vnsLIf name="external">
     <vnsRsMetaIf tDn="uni/infra/mDev-CISCO-ASA-1.2/mIfLbl-external"/>
     <vnsRsCIfAtt tDn="uni/tn-TenantName/lDevVip-ASAv01-cluster/cDev-ASAv01-
active/cIf-[Gig0/0]"/>
</vnsLIf>
<vnsLIf name="internal">
      <vnsRsMetaIf tDn="uni/infra/mDev-CISCO-ASA-1.2/mIfLbl-internal"/>
     <vnsRsCIfAtt tDn="uni/tn-TenantName/lDevVip-ASAv01-cluster/cDev-ASAv01-
active/cIf-[Gig0/1]"/>
 </vnsLIf>
<vnsLIf name="internal2">
      <vnsRsMetaIf tDn="uni/infra/mDev-CISCO-ASA-1.2/mIfLbl-internal"/>
     <vnsRsCIfAtt tDn="uni/tn-TenantName/lDevVip-ASAv01-cluster/cDev-ASAv01-
active/cIf-[Gig0/2]"/>
</vnsLIf>
<vnsLIf name="internal3">
    <vnsRsMetaIf tDn="uni/infra/mDev-CISCO-ASA-1.2/mIfLbl-internal"/>
     <vnsRsCIfAtt tDn="uni/tn-TenantName/lDevVip-ASAv01-cluster/cDev-ASAv01-
active/cIf-[Gig0/3]"/>
</vnsLIf>
```

Assume that you defined three contracts as in the following XML script:

```
<vzBrCP name="c1">
    <vzSubj name="http">
            <vzRsSubjGraphAtt tnVnsAbsGraphName="g1"/>
    </vzSubj>
</vzBrCP>
<vzBrCP name="c2">
    <vzSubj name="http">
            <vzRsSubjGraphAtt tnVnsAbsGraphName="g1"/>
    </vzSubj>
</vzBrCP>
<vzBrCP name="c3">
    <vzSubj name="http">
            <vzRsSubjGraphAtt tnVnsAbsGraphName="g1"/>
    </vzSubj>
```

You can then define a logical device selection policy like the one shown here that selects the same outside interface for each contract (c1, c2, and c3), but a different inside interface for each contract:

```
<vnsLDevCtx ctrctNameOrLbl="c1" graphNameOrLbl="any" nodeNameOrLbl="any">
<vnsRsLDevCtxToLDev tDn="uni/tn-TenantName/lDevVip-ASAv01-cluster"/>
<vnsLIfCtx connNameOrLbl="external">
        <vnsRsLIfCtxToLIf tDn="uni/tn-TenantName/lDevVip-ASAv01-cluster/lIf-
external"/>
        <vnsRsLIfCtxToBD tDn="uni/tn-TenantName/BD-consBD1"/>
 </vnsLIfCtx>
<vnsLIfCtx connNameOrLbl="internal">
        <vnsRsLIfCtxToLIf tDn="uni/tn-TenantName/lDevVip-ASAv01-cluster/lIf-
internal"/>
```

```
        <vnsRsLIfCtxToBD tDn="uni/tn-TenantName/BD-provBD1"/>
</vnsLIfCtx>
</vnsLDevCtx>
<vnsLDevCtx ctrctNameOrLbl="c2" graphNameOrLbl="any" nodeNameOrLbl="any">
       <vnsRsLDevCtxToLDev tDn="uni/tn-TenantName/lDevVip-ASAv01-cluster"/>
       <vnsLIfCtx connNameOrLbl="external">
          <vnsRsLIfCtxToLIf tDn="uni/tn-TenantName/lDevVip-ASAv01-cluster/lIf-
external"/>
          <vnsRsLIfCtxToBD tDn="uni/tn-TenantName/BD-consBD1"/>
       </vnsLIfCtx>
      <vnsLIfCtx connNameOrLbl="internal">
        <vnsRsLIfCtxToLIf tDn="uni/tn-TenantName/lDevVip-ASAv01-cluster/lIf-
internal2"/>
        <vnsRsLIfCtxToBD tDn="uni/tn-TenantName/BD-provBD2"/>
     </vnsLIfCtx>
</vnsLDevCtx>
<vnsLDevCtx ctrctNameOrLbl="c3" graphNameOrLbl="any" nodeNameOrLbl="any">
<vnsRsLDevCtxToLDev tDn="uni/tn-TenantName/lDevVip-ASAv01-cluster"/>
       <vnsLIfCtx connNameOrLbl="external">
          <vnsRsLIfCtxToLIf tDn="uni/tn-TenantName/lDevVip-ASAv01-cluster/lIf-
external"/>
          <vnsRsLIfCtxToBD tDn="uni/tn-TenantName/BD-consBD1"/>
       </vnsLIfCtx>
      <vnsLIfCtx connNameOrLbl="internal">
        <vnsRsLIfCtxToLIf tDn="uni/tn-TenantName/lDevVip-ASAv01-cluster/lIf-
internal3"/>
        <vnsRsLIfCtxToBD tDn="uni/tn-TenantName/BD-provBD3"/>
       </vnsLIfCtx>
</vnsLDevCtx>
```

Deployment Modes

Cisco ACI supports these deployment modes for L4-L7 devices with the service graph:

- Go-to mode (also known as routed mode): In this mode, the default gateway for the servers is the L4-L7 device.
- Go-to mode with service graph redirect: In this mode, the default gateway for the servers is the Cisco ACI bridge domain, and traffic is sent to the L4-L7 device based on the contract configuration between EPGs. Service graph redirect is the preferred deployment mode for the service graph when Cisco Nexus 9300 EX and FX platform switches are used.
- Go-through mode (also known as transparent mode or bridged mode): In this mode, the default gateway for the servers is the client-side bridge domain, and the L4-L7 device bridges the client-side bridge domain and the server-side bridge domain.
- One-arm mode: in this mode, the default gateway for the servers is the server-side bridge domain, and the L4-L7 device is configured for source NAT (SNAT).

Routed Mode (Go-To Mode)

The simplest way to deploy a service graph in routed mode is to use NAT on the L4-L7 device. Cisco ACI also supports service devices deployed in routed mode with either static or dynamic routing by connecting the L4L7 device to a L3Out as described in "Using L3Out for Routing to the L4-L7 Device".

This design requires two bridge domains: one for the client-side, or outside, interface; and one for the server-side, or inside, interface. The default gateway for the servers is the service appliance internal or server-side interface IP address.

The routing from the outside (clients) to the service device to the inside (servers) can be provided by the fabric itself (through a VRF instance) or by an external router.

This document divides the routed mode designs into these categories:

- Routed mode with outside Layer 2 bridge domain: In this design, the outside of the service graph connects to a Layer 2 bridge domain. The routing to the service device is implemented with an external routing device.
- Routed mode with L3Out and NAT: In this design, the service graph connects to the outside network through routing provided by the Cisco ACI fabric. This design can be implemented if the service device implements NAT, as in the case of a load balancer or in the case of a firewall that is translating the internal IP addresses.
- Routed mode in which the L3Out interface performs Layer 3 peering with the L4-L7 device: In this design, the L4-L7 device doesn't use NAT to translate the addresses of the servers. Therefore, you need to configure static or dynamic routing on the L3Out interface with the L4-L7 device.
- Routed mode with Policy-Based Redirect (PBR) to the L4-L7 device: In this design, you don't need L3out or NAT on the L4-L7 device. The Cisco ACI fabric redirects traffic to the L4-L7 device based on contracts.
- Routed mode with outside Layer 2 bridge domain: In this design, the L4-L7 service may or may not be configured to translate the IP addresses of the servers, as may be the case with a firewall configuration (Figure 34). In addition, in this design you use an external router to provide the default gateway to the service device.

Figure 34. Topology of a Firewall Deployed in Routed Mode

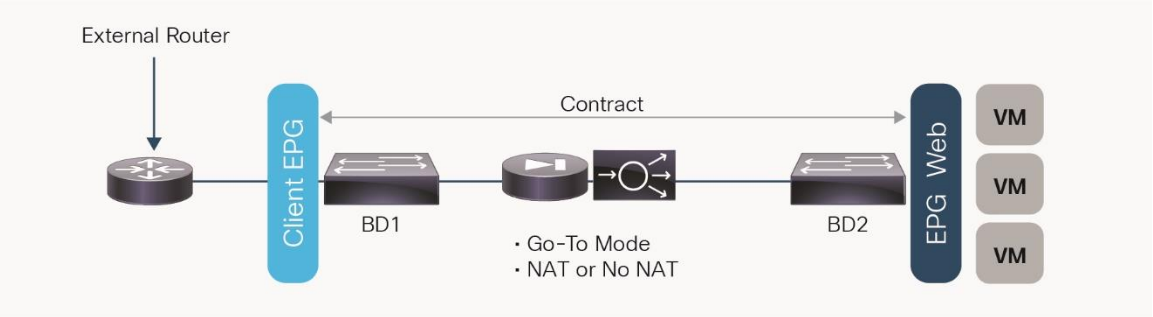


Figure 34 shows a design in which both the outside and the inside bridge domains are Layer 2 only. In this case, the bridge domains are associated with the tenant VRF instance just for consistency with the policy model. Bridge domains can be tuned for flood reduction, which can be useful for BD2.

In the case in the figure, creating a contract between a client-side EPG and a server-side EPG achieves the service graph configuration.

The L4-L7 device provides the default gateway for the servers.

Routed Mode with L3Out and NAT

If the service device uses NAT to translate the IP addresses of the servers, as in the case of a load balancer, you can choose to use a VRF instance from the fabric to provide routing from the outside interface to the service device. This approach uses an L3Out interface on the outside (Figure 35).

Figure 35. Topology of a Load Balancer Deployed in Routed Mode with L3Out

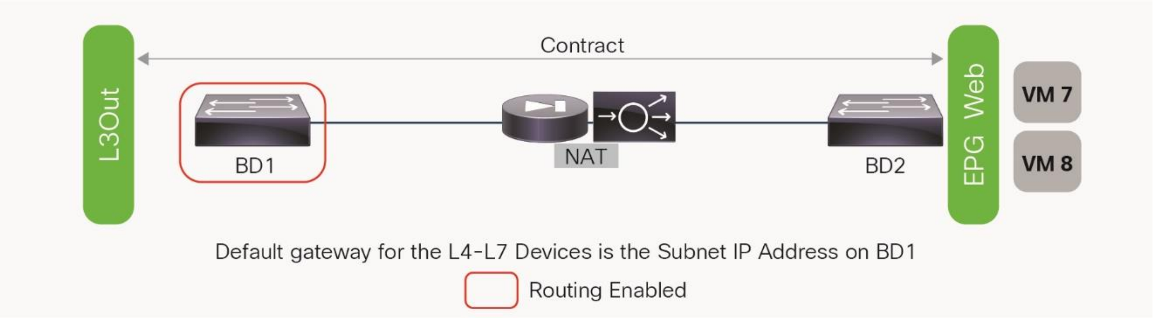

Contract
L3Out
BD1
NAT
BD2
EPG Web
VM 7
VM 8
Default gateway for the L4-L7 Devices is the Subnet IP Address on BD1
Routing Enabled

Figure 35 shows a design in which the load balancer is placed between an L3Out instance and the servers. The internal Bridge Domain (BD2) doesn’t offer any routing for the servers. The VRF instance of the tenant is associated with the internal bridge domain just for consistency with the Cisco ACI object model. Because you need to create a VRF (or private network) for a given tenant, you do not need to create another one explicitly for the service graph; you can simply use the existing tenant VRF instance for the bridge domains used by the service graph.

The L4-L7 device provides the default gateway for the servers.

The routing on the L4-L7 device uses static routes pointing to the subnet of the outside bridge domain.

The outside bridge domain in this figure offers routing for the service appliance. The subnet address of the outside bridge domain is the default gateway of the service appliance. The VRF instance of the tenant is associated with the outside bridge domain. The routing to the outside is implemented by configuring an L3Out instance.

Because BD1 has routing enabled, you need to make sure that BD1 learns only the NAT addresses of the virtual machines by configuring Limit IP Learning to Subnet (which was previously called Subnet Check). You also need to make sure that a maximum of 1024 IP addresses are learned on this interface (based on the verified scalability limits for Cisco ACI Release 2.3), and that the IP addresses are aged independently by configuring IP Aging.

In the case of this design, the service graph configuration is achieved by creating a contract between the L3Out EPG (L3InstP) and the server EPG.

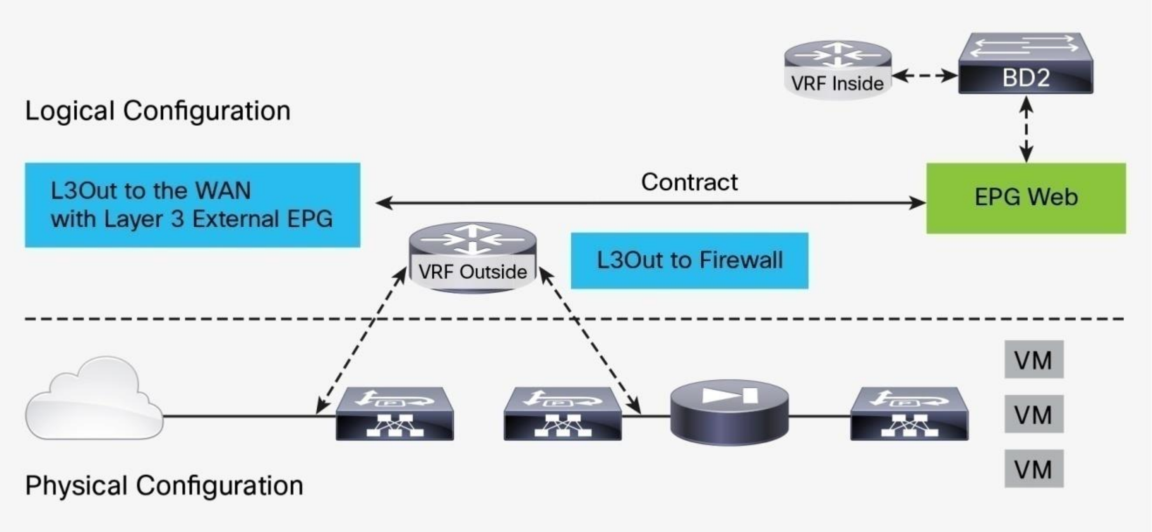
Routed Mode with L3Out Routing to the L4-L7 Device

This design consists of two VRF instances: one to provide route peering with the outside of the Cisco ACI fabric and to the outside or client-side interface of a firewall or a load balancer, and another for the server farm. Note that you don’t need to use two bridge domains for this design; you can have only one for the servers.

The bridge domain doesn't need to be configured for routing. The server default gateway then would be the L4-L7 device.

Figure 36 illustrates this design.

Figure 36. Topology of a Routed L4-L7 Deployment with Static or Dynamic Routing to the L4-L7 Device



The VRF outside instance has two L3Out interfaces: one configured for routing to the WAN, and one configured for routing to the firewall. The contract for this service graph is established between the L3Out interface to the WAN and the server EPG. The consumer connector of the service graph is configured to be associated with the L3Out external network interface to the firewall.

The outside connector of the service graph must also be configured for adjacency type Layer 3 and for unicast routing.

You can find the connector configuration under Tenant > L4-L7 Services > L4-L7 Service Graph Templates by selecting a template and then selecting the Policy tab, under Connections.

In this design, you may want to tune BD2 to reduce flooding.

If the active-standby L4-L7 device pair is connected to first-generation leaf switches with vPC and static routing, make sure that the active and standby devices both connect to the same leaf pairs. If instead they are connected to Cisco Nexus 9300 EX or FX platform switches, make sure that you use Cisco ACI Release 2.3 or later and configure Fabric > Access Policies > Global Policies > Fabric Wide Setting Policy in order to select the option called Disable Remote EP Learn.

If the active-standby L4-L7 device pair is connected to a fabric that includes both first- and second-generation leaf switches, and if servers are connected to the same leaf switches as the L4-L7 devices, you should configure one of these options:

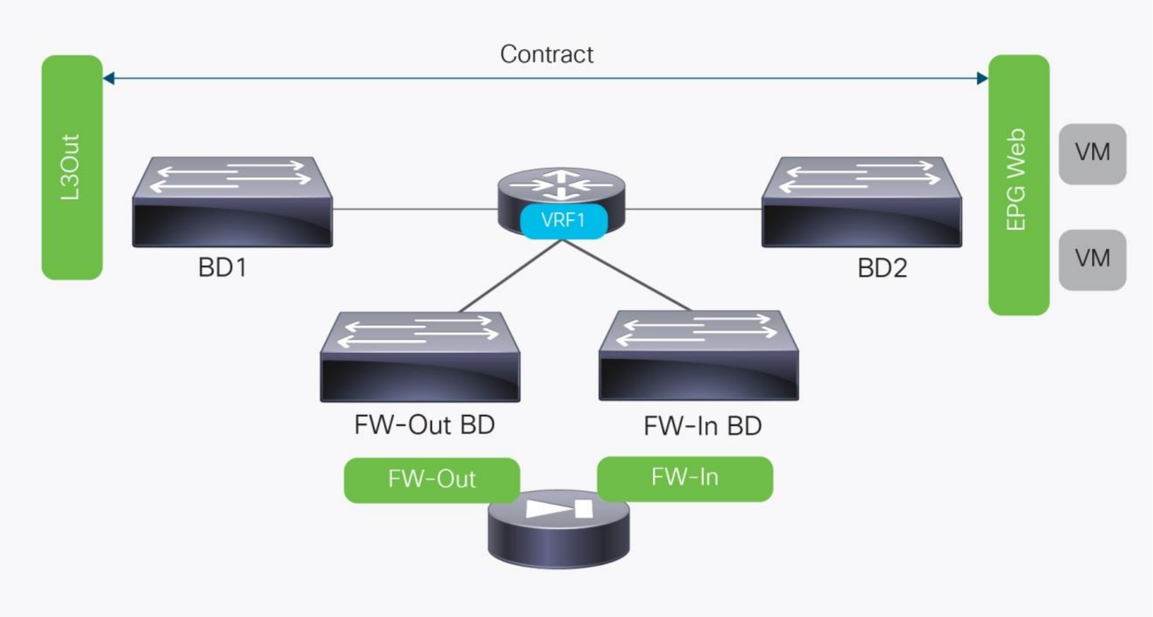
- You can configure VRF outside for egress filtering.
- Alternatively, if the fabric is running Cisco ACI Release 2.2(2e) or later, you should disable remote endpoint learning for the border leaf switches by going to Fabric > Access Policies > Global Policies > Fabric Wide Setting Policy and selecting Disable Remote EP Learn.

For more information, refer to the section "Using L3Out for Routing to the L4L7 Device."

Routed Mode with PBR to the L4-L7 Device

Another deployment model you can use is PBR. Unlike previous design options, PBR doesn’t require L3Out for the service node, two VRF instances, or NAT. Using PBR, Cisco ACI fabric can route traffic to the service node based on the source EPG, the destination EPG, and contract filter matching. The bridge domain needs to be configured for routing. The server default gateway and service node (PBR node) gateway must be a Cisco ACI fabric bridge domain subnet (Figure 37).

Figure 37. Topology of a Routed L4-L7 Deployment with PBR to the L4-L7 Device

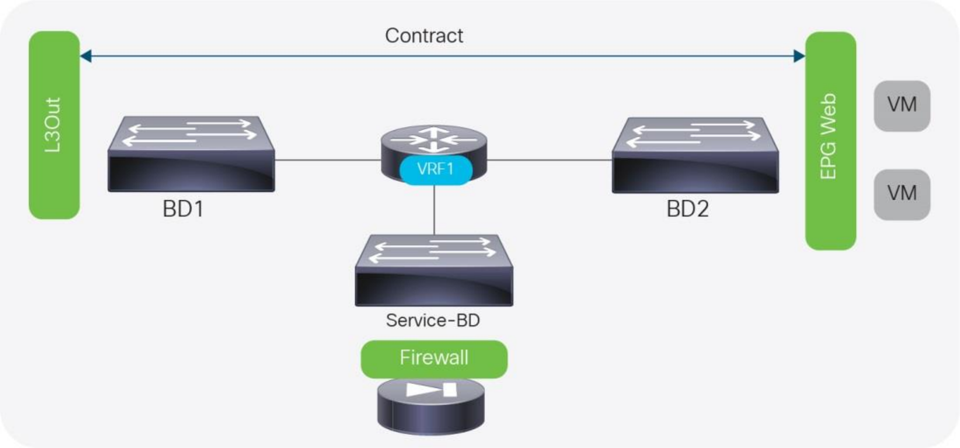


The PBR node has two interfaces: one configured for the consumer side and one configured for the provider side. Both PBR node connectors must be in a bridge domain and must not be in the consumer or provider bridge domain. You thus need a service bridge domain, and the connectors must be configured for unicast routing. This service bridge domain requirement will be removed in Cisco ACI Release 3.1.

PBR requires a service graph, and the PBR node must be in go-to mode. PBR can be used in a one-arm mode deployment as well (Figure 38).

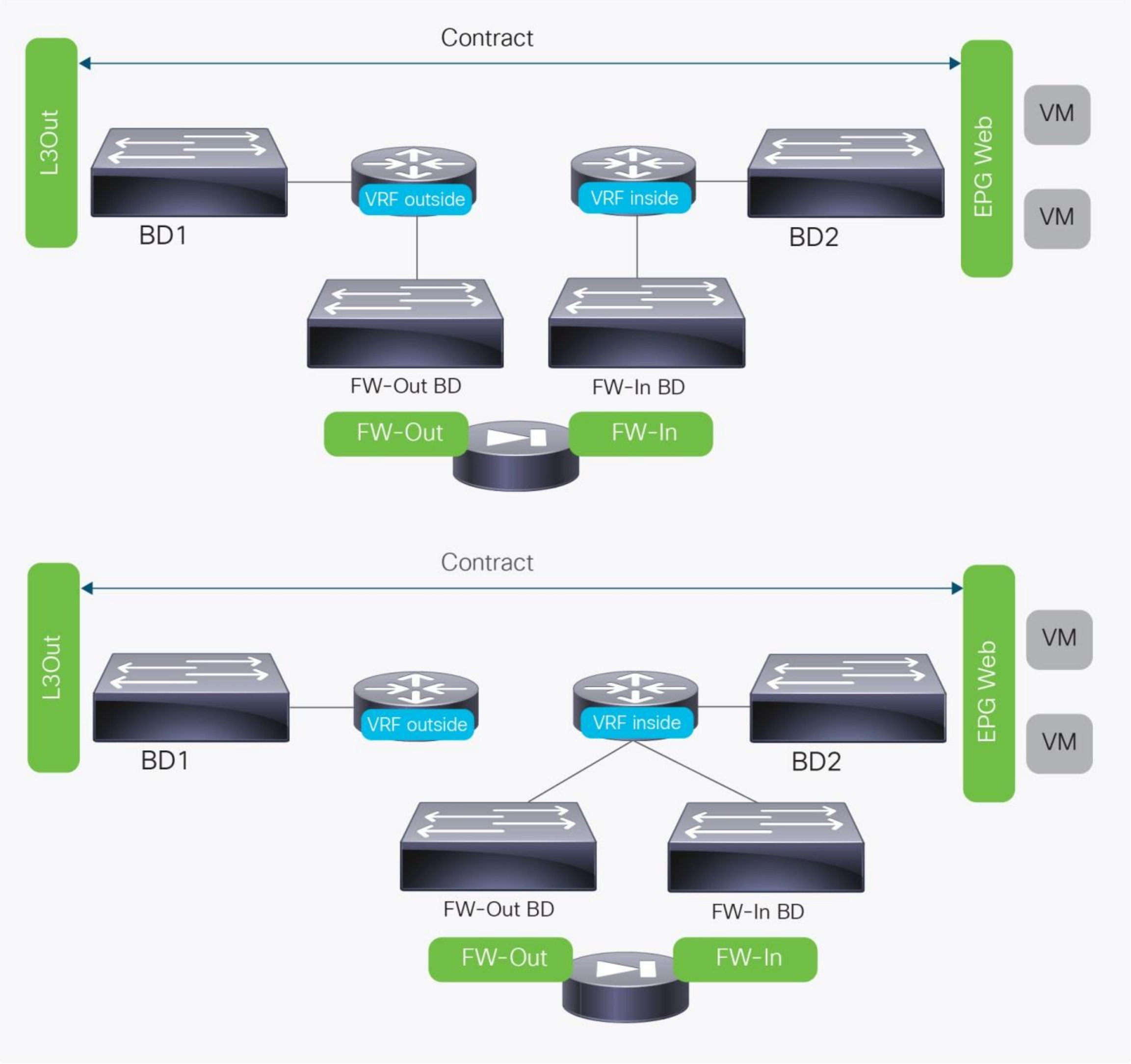
Note: For one-arm deployments make sure that your firewall allows traffic to be routed in and out the same security zone interface.

Figure 38. Topology of a Routed L4-L7 Deployment with PBR One-Arm Mode



PBR also can be used in a two-VRF-instance design with route leaking. You can place a PBR device between consumer and provider VRF instances or in either of them, as in Figure 39.

Figure 39. Topology of a Routed L4-L7 Deployment with PBR in Two VRF Instances



For more information about PBR, see the Layer 4 to Layer 7 services deployment guide at https://www.cisco.com/c/en/us/td/docs/switches/datacenter/aci/apic/sw/1-x/L4-L7_Services_Deployment/guide/b_L4L7_Deploy_ver211.html.

Transparent Mode (Go-Through Mode)

The design requires two bridge domains. In transparent mode, the L4-L7 device is deployed in pass-through (go-through) mode. The service device doesn't provide the default gateway for the servers. The servers' default gateway is either the subnet on the outside bridge domain or an external router. The routing from the outside (clients) to the inside (servers) interfaces can be provided by the fabric itself (through a VRF instance) or by an external router.

With go-through mode, Cisco ACI doesn't let you configure IP routing on both bridge domains, and even if you configure hardware proxy, Cisco ACI will set the bridge domain for unknown unicast flooding and ARP flooding.

This document divides the transparent mode designs into two categories:

- Transparent mode with outside Layer 2 bridge domain: In this design, the outside of the service graph connects to a Layer 2 bridge domain. The routing to the service device is implemented with an external routing device.
- Transparent mode with L3Out: In this design, the service graph connects to the outside network through routing provided by the Cisco ACI fabric.

Transparent Mode with Outside Layer 2 Bridge Domain

Figure 40 shows a transparent mode deployment with routing provided by an external router.

The design requires two bridge domains. The default gateway for the servers is the IP address of the external router. Tuning the bridge domains for flooding reduction is not possible because the service graph ensures that Layer 2 unknown unicast flooding is enabled.

Figure 40. Firewall Deployed in Transparent Mode with Routing Outside the Fabric

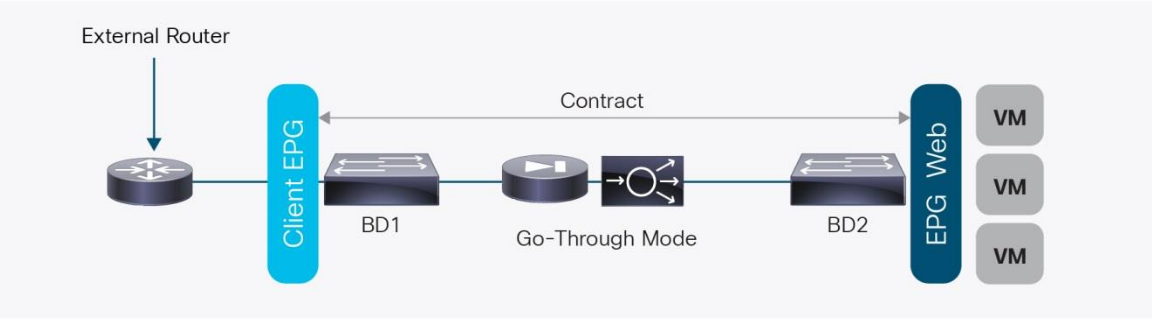
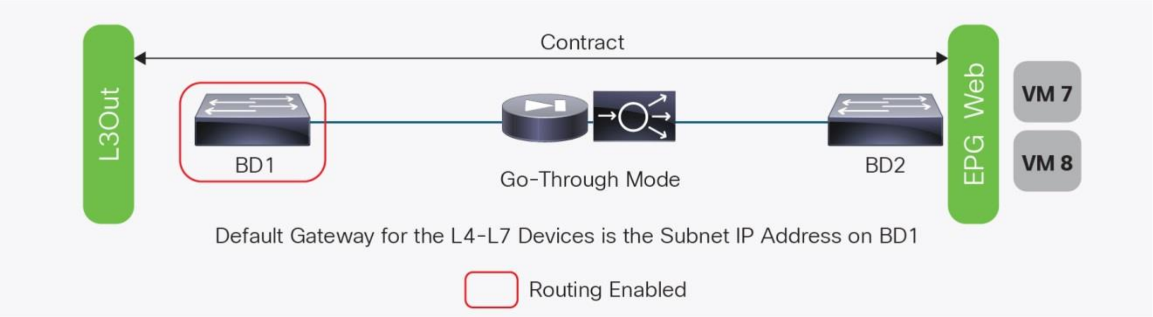


Figure 41 shows a transparent mode deployment with routing provided by the Cisco ACI fabric.

This design requires two bridge domains. The default gateway for the servers is the IP address of the subnet of the outside bridge domain. Because IP routing is enabled on BD1, the IP addresses of the endpoints in BD2 are learned as if they were in BD1, and they are associated with the MAC address of the L4-L7 device.

Because BD1 has routing enabled, you need to make sure that BD1 learns only the addresses of the subnet that you defined. Thus, you should configure Limit IP Learning to Subnet (which was previously called Subnet Check). You also need to make sure that a maximum of 1024 IP addresses are learned on this interface (based on the verified scalability limits for Cisco ACI Release 2.3), and that the IP addresses are aged independently by configuring IP Aging.

Figure 41. Firewall Deployed in Transparent Mode with Routing Provided by the Cisco ACI Fabric


Contract
L3Out
BD1
Go-Through Mode
BD2
EPG Web
VM 7
VM 8
Default Gateway for the L4-L7 Devices is the Subnet IP Address on BD1
Routing Enabled

One-Arm Mode

Figure 42 shows a one-arm mode deployment with the classic networking constructs. Figure 43 shows the same topology in Cisco ACI.

In one-arm mode, the default gateway for the servers is the router upstream. The load balancer is connected with one VLAN to the router as well, which is the default gateway for the load balancer itself. The load balancer uses source NAT for the traffic from the clients to the servers to help ensure receipt of the return traffic.

The default gateway for the servers is the subnet on BD2. The default gateway for the load balancer is the subnet on BD3.

The contract is established between the external EPG and the server EPG, and it is associated with the service graph.

This topology has three bridge domains: one bridge domain for the outside, or client side (BD1); one bridge domain for the inside, or server side (BD2); and one bridge domain for connectivity with the load balancer (BD3). The VRF instance is associated with all three bridge domains. With this setup, you can optimize flooding on BD2.

On BD3 the load balancer forwards traffic from the clients to the servers by routing it through the Cisco ACI fabric. Therefore, you need to make sure that the only addresses learned in BD3 are the ones that belong to the BD3 subnet: that is, the virtual addresses announced by the load balancer and the NAT addresses.

You should configure Limit IP Learning to Subnet (which was previously called Subnet Check) on BD3. You also need to make sure that a maximum of 1024 IP addresses are learned on this interface (based on the verified scalability limits for Cisco ACI Release 2.3), and that the IP addresses are aged independently by configuring IP Aging.

Figure 42. Deployment of a Load Balancer in One-Arm Mode

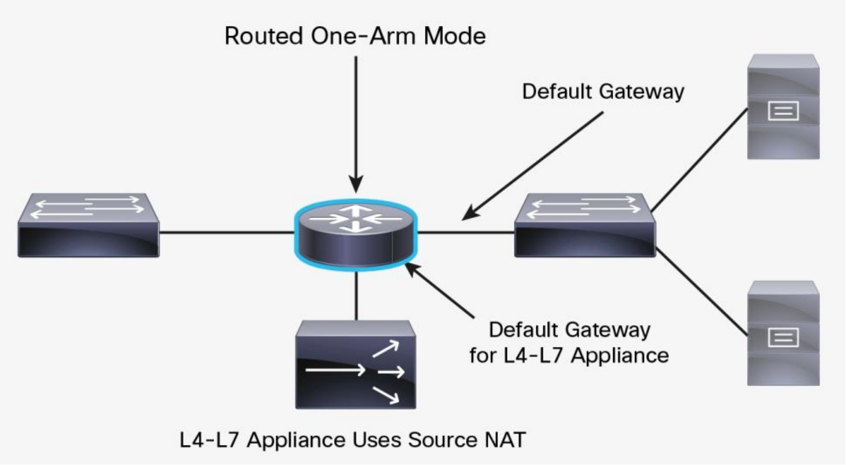
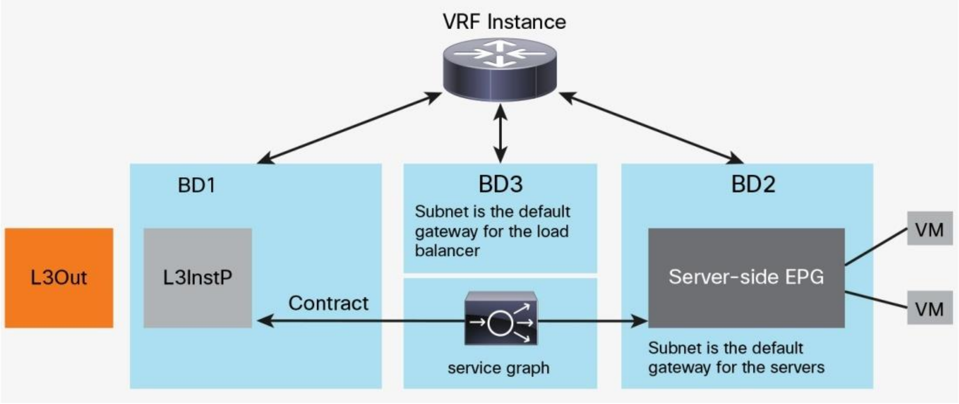


Figure 43. Load Balancer Deployed in One-Arm Mode in Cisco ACI


VRF Instance
BD1
BD3
Subnet is the default gateway for the load balancer
BD2
L3Out
L3InstP
Contract
service graph
Server-side EPG
VM
VM
Subnet is the default gateway for the servers

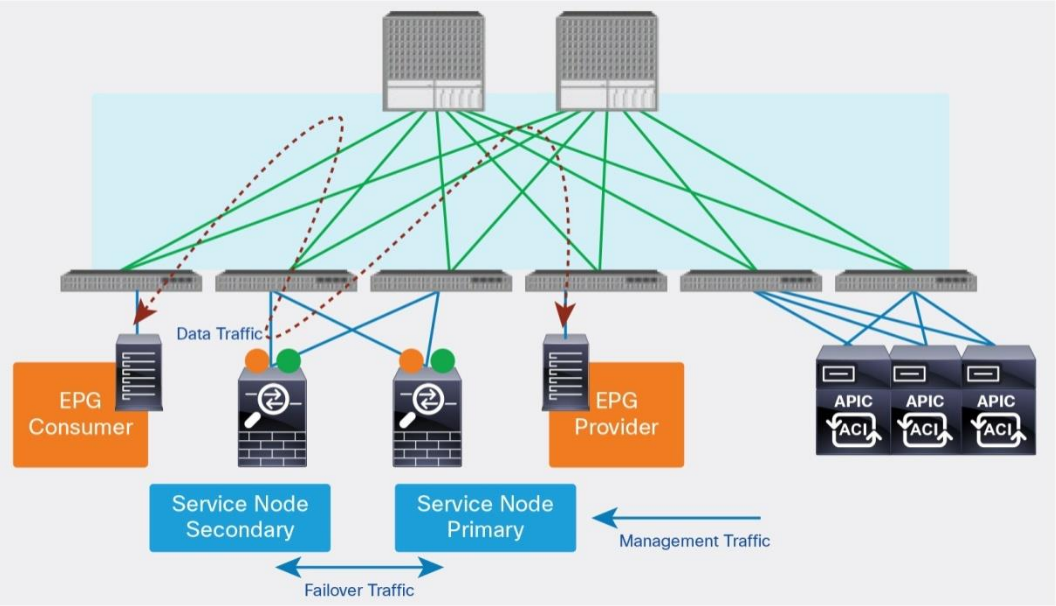
Physical Topology Choices

Typically, a service device carries three types of traffic:

- Management traffic between the APIC and the service node
- Data traffic
- Failover traffic between service nodes (if service-node high availability is needed)

This section describes the topology choices for this traffic (Figure 44).

Figure 44. Physical Topology

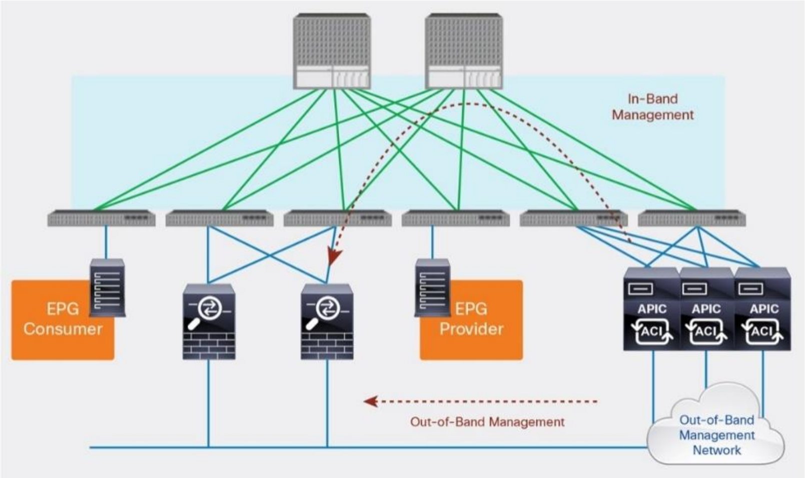


Management Traffic

To push policy from the APIC to the service node, management connectivity between the nodes is needed. Cisco ACI fabric supports out-of-band management and in-band management, and both options are supported in an L4-L7 device configuration (Figure 45):

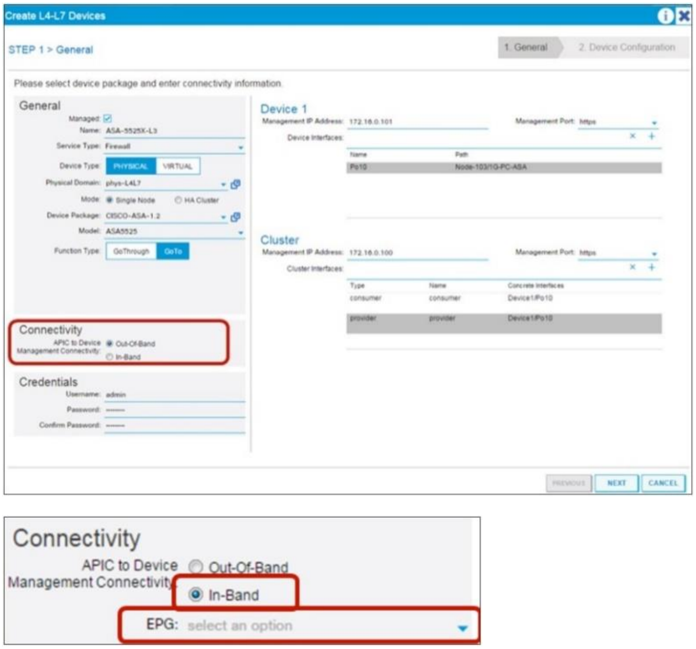
- Out-of-band management: Use the APIC out-of-band management interface for communication with service nodes. In this case, the management network is placed outside the Cisco ACI fabric.
- In-band management: Use the APIC in-band management interface for communication with service nodes. In this case, the management network is placed within the Cisco ACI fabric.

Figure 45. Management Network



By default, out-of-band management is selected. If you select in-band management, you need to create an EPG for the service node management interface and select it in the L4-L7 device configuration (Figure 46).

Figure 46. L4-L7 Device Configuration



Create L4-L7 Devices

STEP 1 > General

1. General — 2. Device Configuration

Please select device package and enter connectivity information.

General

Managed: ☑
Name: ASA-5525X-L3
Service Type: Firewall
Device Type: [✓ PHYSICAL] VIRTUAL
Physical Domain: phys-L4L7
Mode: ● Single Node ○ HA Cluster
Device Package: CISCO-ASA-1.2
Model: ASA5525
Function Type: GoThrough [✓ GoTo]

Connectivity

APIC to Device Management Connectivity: ● Out-Of-Band ○ In-Band

Credentials

Username: admin
Password: --------
Confirm Password: --------

Device 1

Management IP Address: 172.16.0.101
Management Port: https
Device Interfaces:

Name	Path
Po10	Node-103/1G-PC-ASA

Cluster

Management IP Address: 172.16.0.100
Management Port: https
Cluster Interfaces:

Type	Name	Concrete Interfaces
consumer	consumer	Device1/Po10
provider	provider	Device1/Po10

Connectivity

APIC to Device Management Connectivity: ○ Out-Of-Band ● In-Band

EPG: select an option

Note: If the APIC has both out-of-band and in-band management IP addresses, the default route using in-band management is preferred. If the APIC has both addresses and you want to use out-of-band management for communication with the L4-L7 device, you need to make sure that the L4-L7 management IP address and the APIC out-of-band management IP address are in the same subnet.

Data Traffic

To set up end-to-end connectivity between EPGs through the service node, you need to create data path networks for service nodes. This process is performed automatically during service graph rendering. This section describes domain and VLAN pool configuration for data traffic on both physical and virtual service devices.

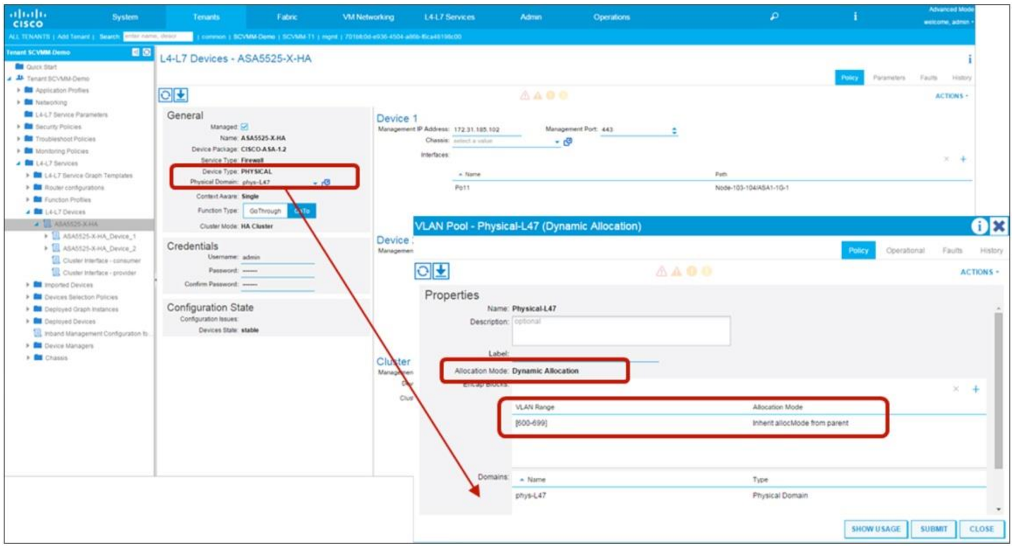
Physical Appliances (Managed Mode)

For the physical domain in managed mode, use dynamic allocation mode for the VLAN range for the L4-L7 device (Figure 47). The APIC will select VLANs from the VLAN range, configure the Cisco ACI fabric, and configure the service device with the VLANs accordingly during service graph rendering.

The physical domain can contain a VLAN range set with static allocation mode, but the VLAN range specified with dynamic allocation mode will be used for service graph deployment.

For L3Out route peering, the APIC will select the VLAN in the L3Out logical interface profile configuration.

Figure 47. Physical Appliance Configuration (Managed Mode)



L4-L7 Devices - ASA5525-X-HA

General

Managed: ☑

Name: ASA5525-X-HA

Device Package: CISCO-ASA-1.2

Service Type: Firewall

Device Type: PHYSICAL

Physical Domain: phys-L47

Context Aware: Single

Function Type: GoThrough | GoTo

Cluster Mode: HA Cluster

Credentials

Username: admin

Password: ------

Confirm Password: ------

Configuration State

Configuration Issues:

Devices State: stable

Device 1

Management IP Address: 172.31.185.102 Management Port: 443

Chassis: select a value

Interfaces:

Name	Path
Po11	Node-103-104/ASA1-1G-1

VLAN Pool - Physical-L47 (Dynamic Allocation)

Properties

Name: Physical-L47

Description: optional

Label:

Allocation Mode: Dynamic Allocation

Encap Blocks:

VLAN Range	Allocation Mode
[600-699]	Inherit allocMode from parent

Domains:

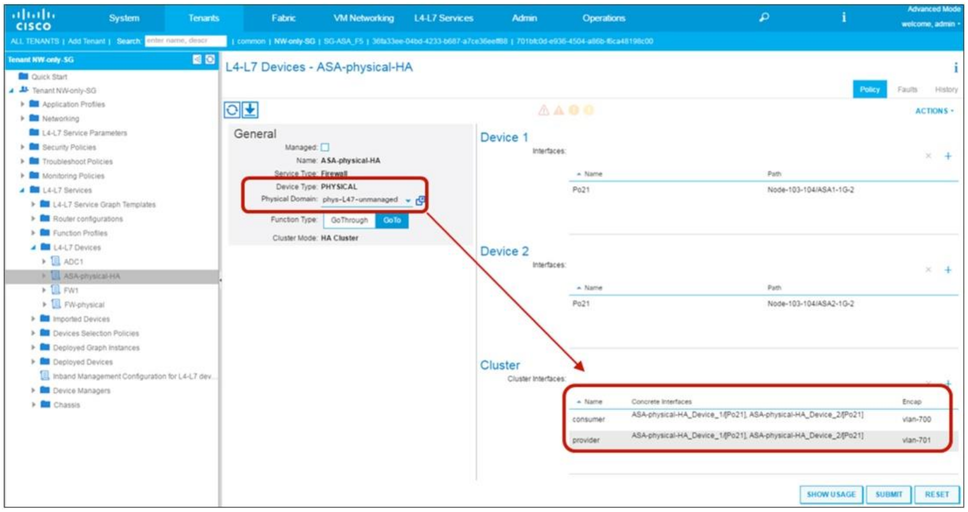
Name	Type
phys-L47	Physical Domain

Physical Appliances (Unmanaged Mode)

In unmanaged mode, specify the physical domain with the static allocation mode for the VLAN range for the L4-L7 device.

Specify the path and VLAN ID in the cluster interface, which are similar to the specifications for static path bindings for the EPG (Figure 48).

Figure 48. Physical Appliance Configuration (Unmanaged Mode)



L4-L7 Devices - ASA-physical-HA

General

Managed: □
Name: ASA-physical-HA
Service Type: Firewall
Device Type: PHYSICAL
Physical Domain: phys-L47-unmanaged
Function Type: GoThrough [✓ GoTo]
Cluster Mode: HA Cluster

Device 1

Interfaces:

Name	Path
Po21	Node-103-104/ASA1-1G-2

Device 2

Interfaces:

Name	Path
Po21	Node-103-104/ASA2-1G-2

Cluster

Cluster Interfaces:

Name	Concrete Interfaces	Encap
consumer	ASA-physical-HA_Device_1/[Po21], ASA-physical-HA_Device_2/[Po21]	vlan-700
provider	ASA-physical-HA_Device_1/[Po21], ASA-physical-HA_Device_2/[Po21]	vlan-701

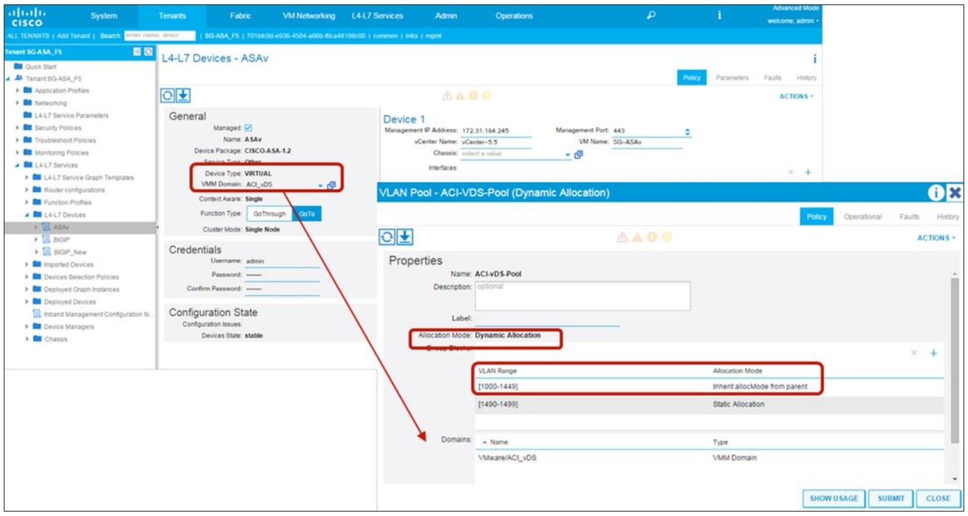
Virtual Appliances (Managed Mode and Unmanaged Mode)

For virtual appliances in both managed and unmanaged modes, specify the Virtual Machine Manager (VMM) domain using the dynamic allocation mode for the VLAN range for the L4-L7 device (Figure 49). The APIC will select VLANs from the VLAN range, configure the Cisco ACI fabric, create port groups for the service node connector, and change the vNIC configuration of the virtual appliance during service graph rendering.

The VMM domain can also contain a VLAN range that uses static allocation mode, but the VLAN range specified with dynamic allocation mode will be used for service graph deployment.

For L3Out route peering, the APIC selects the VLAN that is used in the L3Out logical interface profile configuration.

Figure 49. Virtual Appliance Configuration



L4-L7 Devices - ASAv

General

Managed: ☑
Name: ASAv
Device Package: CISCO-ASA-1.2
Device Type: VIRTUAL
VMM Domain: ACI_vDS
Context Aware: Single
Function Type: GoThrough GoTo
Cluster Mode: Single Node

Credentials

Username: admin
Password: ------
Confirm Password: ------

Configuration State

Configuration Issues:
Devices State: stable

Device 1

Management IP Address: 172.31.184.245
Management Port: 443
vCenter Name: vCenter-5.5
VM Name: SG-ASAv
Chassis: select a value
Interfaces:

VLAN Pool - ACI-VDS-Pool (Dynamic Allocation)

Properties

Name: ACI-vDS-Pool
Description: optional
Label:
Allocation Mode: Dynamic Allocation

VLAN Range	Allocation Mode
[1000-1449]	Inherit allocMode from parent
[1490-1499]	Static Allocation

Domains:

Name	Type
VMware/ACI_vDS	VMM Domain

Note: As of this writing, automatic vNIC placement is supported for the virtual appliance running in the VMware VMM domain only. Trunk port groups are not supported. You thus need to create a different vNIC on the virtual appliance for each connector for different cluster interfaces (a shadow EPG).

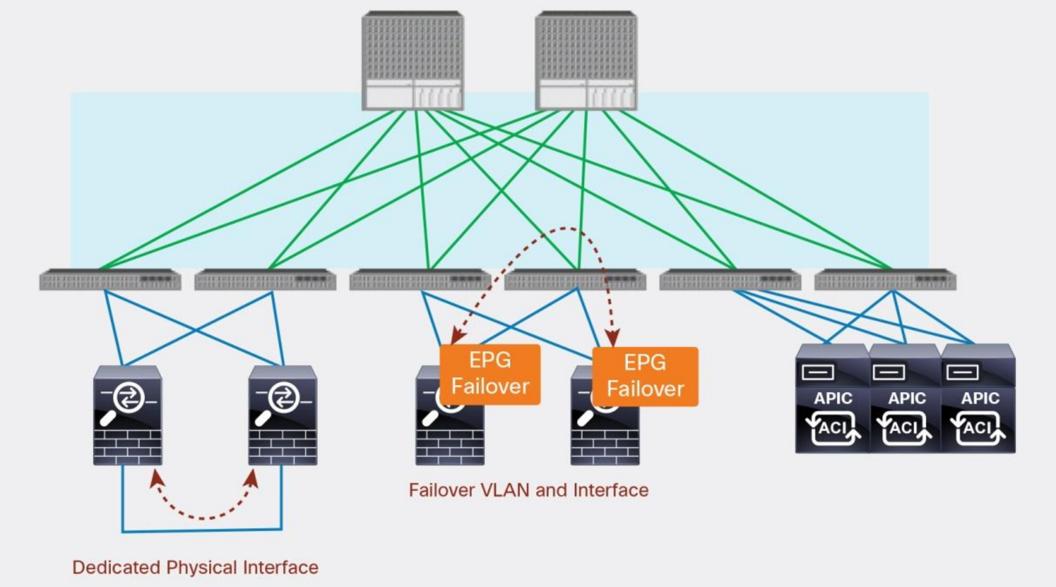
Failover Traffic

Each service device vendor has different failover link options and mechanisms (Figure 50). Typical options are listed here:

- Dedicated physical interface for failover traffic (for example, F5 devices): The service device has a dedicated physical interface for failover traffic only.
- Created failover VLAN and interface (for example, Cisco ASA devices): The service device doesn't have a dedicated physical interface. You need to create a failover VLAN or choose interfaces for failover traffic, which typically are created on different physical interfaces, with one for data traffic.
- Shared (not dedicated) VLAN and logical interface (for example, Citrix devices): Failover traffic is exchanged over the same VLAN as data traffic.

Typically, use of a dedicated physical interface and a directly cabled pair of failover devices is recommended. If failover interfaces are connected to each service device directly, Cisco ACI fabric doesn't have to manage the failover network. If you prefer to in-band failover traffic within Cisco ACI fabric, you need to create an EPG for failover traffic.

Figure 50. Failover Network Design Option



High-Availability Design and Configuration

This section describes high-availability design and configuration for both physical and virtual appliances: in particular, ASA appliances. ASA appliances don't have dedicated physical interfaces for failover traffic, so you need to create failover interfaces: a failover link and a stateful failover link. These interfaces are for failover communication only and are commonly used as individual interfaces.

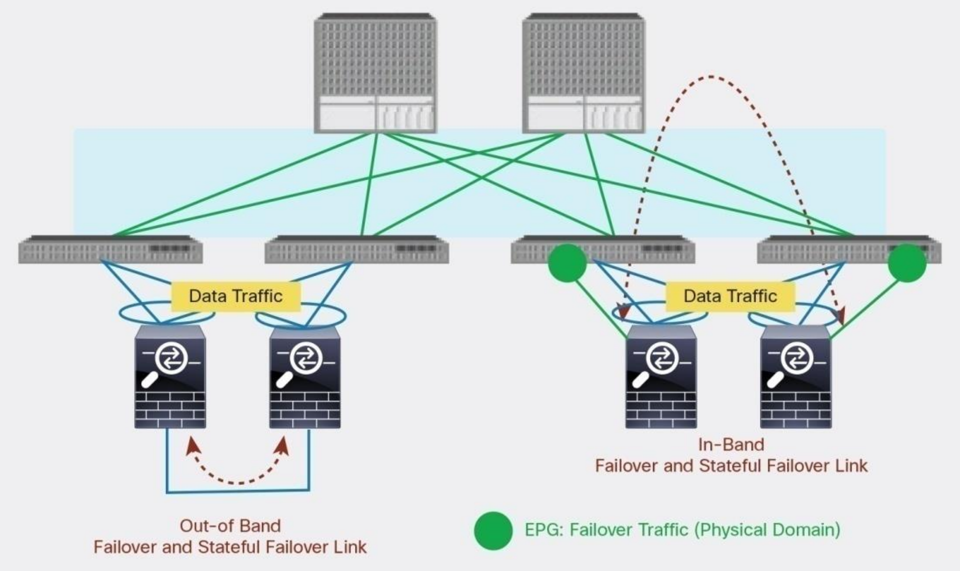
For detailed information about ASA failover, please see document at https://www.cisco.com/c/en/us/td/docs/security/asa/asa95/configuration/general/asa-95-general-config/ha-failover.html.

If failover traffic is within the Cisco ACI fabric (in band), you need to configure an EPG for failover traffic. If the service device is a virtual appliance, you also need to configure vNICs for the virtual appliance, because the APIC doesn't do this automatically.

High-Availability Connectivity from the Physical Appliance to the Fabric

ASA doesn't allow user data traffic and failover traffic to share interfaces, even with different subinterfaces. You must use a separate dedicated interface for the failover link. On the Cisco ACI fabric, you need to create an EPG with static bindings for failover traffic. You can use different EPGs for the failover link and the stateful failover link (Figure 51).

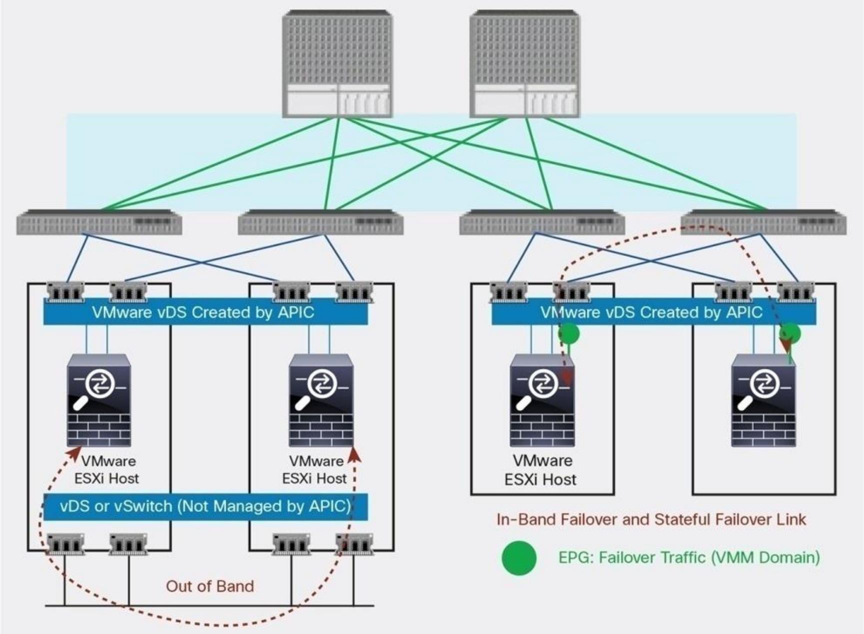
Figure 51. Physical Appliance Connectivity


Data Traffic
Data Traffic
In-Band
Failover and Stateful Failover Link
Out-of Band
Failover and Stateful Failover Link
EPG: Failover Traffic (Physical Domain)

High-Availability Connectivity from the Virtual Appliance to the Fabric

You need to create an EPG for the VMM domain for failover traffic (Figure 52), which create port-groups for the EPG. Then you need to configure vNICs for the virtual appliance. You can use an EPG with static bindings if you don't want to use the VMware VMM domain. In this case, you manually create a port group for failover traffic and configure static bindings for the EPG.

Figure 52. Virtual Appliance Connectivity


VMware vDS Created by APIC
VMware ESXi Host
VMware ESXi Host
vDS or vSwitch (Not Managed by APIC)
Out of Band
VMware vDS Created by APIC
VMware ESXi Host
In-Band Failover and Stateful Failover Link
EPG: Failover Traffic (VMM Domain)

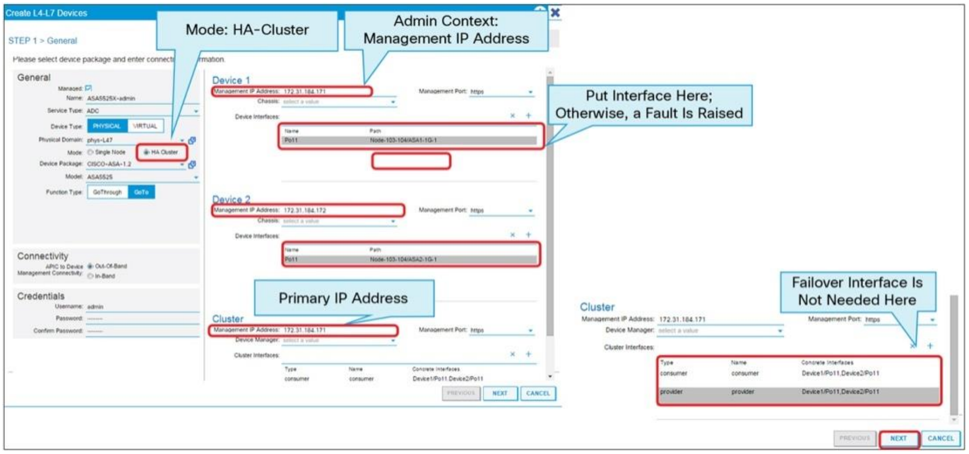
Deploying Redundant Physical Appliances

For a physical ASA device, you typically use multicontext mode. In this case, the failover configuration is in the admin context, which you don’t need to configure multiple times for each virtual context, so you can set up failover configuration manually, without using APIC. To set up failover configuration using APIC, you need to register the admin context as a L4-L7 device (Figure 53), but it won’t be used as the firewall for actual service graph deployment.

Note: You don’t have to configure a cluster interface for the failover link and stateful failover link in the L4-L7 device. If failover traffic is not within the Cisco ACI fabric (if it is out of band), Cisco ACI fabric doesn’t have to manage failover traffic. Even though failover traffic is within the Cisco ACI fabric (in band), the L4-L7 device configuration on the APIC doesn’t manage EPG creation for failover traffic. You need to create an EPG for failover traffic.

For each service graph deployment, you need to create a virtual context and add it as an L4-L7 device on the APIC.

Figure 53. L4-L7 Device Configuration



Create L4-L7 Devices

STEP 1 > General

Please select device package and enter connecti[...]rmation.

General
Managed: ☑
Name: ASA5525X-admin
Service Type: ADC
Device Type: [✓ PHYSICAL] VIRTUAL
Physical Domain: phys-L47
Mode: ○ Single Node ● HA Cluster
Device Package: CISCO-ASA-1.2
Model: ASA5525
Function Type: GoThrough [✓ GoTo]

Connectivity
APIC to Device Management Connectivity: ● Out-Of-Band ○ In-Band

Credentials
Username: admin
Password: --------
Confirm Password: --------

Device 1
Management IP Address: 172.31.184.171 Management Port: https
Chassis: select a value
Device Interfaces:

Name	Path
Po11	Node-103-104/ASA1-1G-1

Device 2
Management IP Address: 172.31.184.172 Management Port: https
Chassis: select a value
Device Interfaces:

Name	Path
Po11	Node-103-104/ASA2-1G-1

Cluster
Management IP Address: 172.31.184.171 Management Port: https
Device Manager: select a value
Cluster Interfaces:

Type	Name	Concrete Interfaces
consumer	consumer	Device1/Po11,Device2/Po11
provider	provider	Device1/Po11,Device2/Po11

Mode: HA-Cluster

Admin Context: Management IP Address

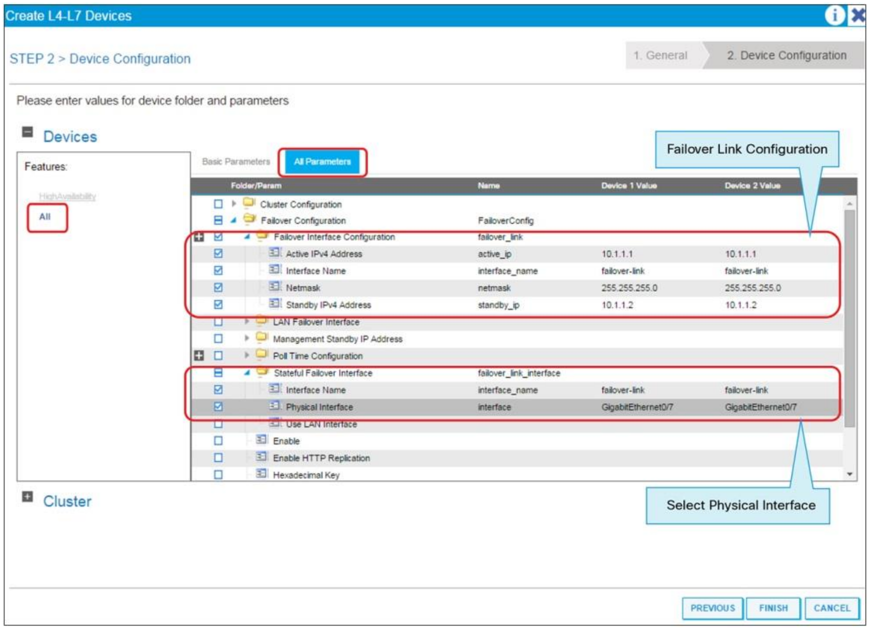
Put Interface Here; Otherwise, a Fault Is Raised

Primary IP Address

Failover Interface Is Not Needed Here

You can use the APIC to configure failover on ASA (Figures 54 and 55).

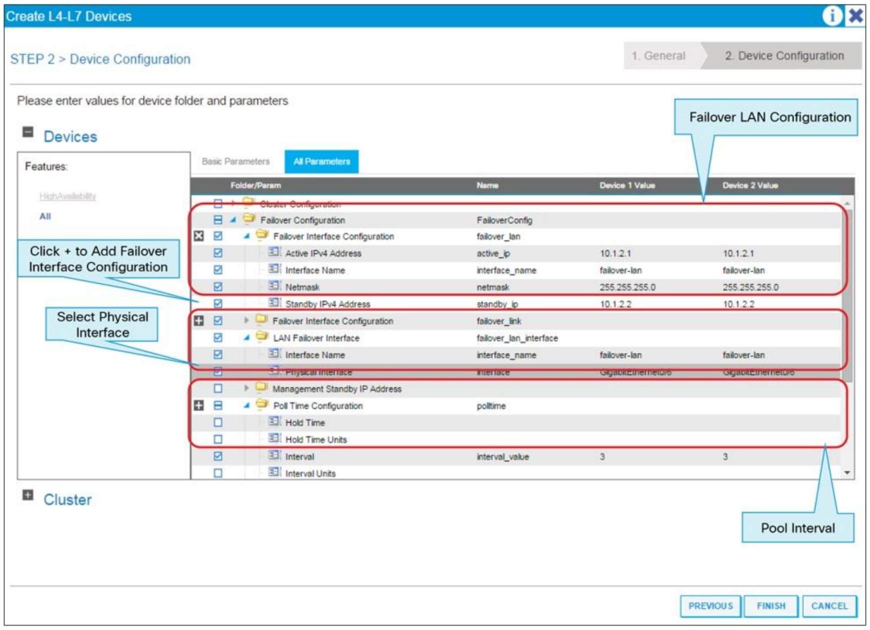
Figure 54. Stateful Failover Link Configuration



Please enter values for device folder and parameters

	Folder/Param	Name	Device 1 Value	Device 2 Value
	□ Cluster Configuration			
	⊟ Failover Configuration	FailoverConfig		
⊞	☑ Failover Interface Configuration	failover_link		
	☑ Active IPv4 Address	active_ip	10.1.1.1	10.1.1.1
	☑ Interface Name	interface_name	failover-link	failover-link
	☑ Netmask	netmask	255.255.255.0	255.255.255.0
	☑ Standby IPv4 Address	standby_ip	10.1.1.2	10.1.1.2
	□ LAN Failover Interface			
	□ Management Standby IP Address			
⊞	□ Poll Time Configuration			
	⊟ Stateful Failover Interface	failover_link_interface		
	☑ Interface Name	interface_name	failover-link	failover-link
	☑ Physical Interface	interface	GigabitEthernet0/7	GigabitEthernet0/7
	□ Use LAN Interface			
	□ Enable			
	□ Enable HTTP Replication			
	□ Hexadecimal Key			

Figure 55. Failover Link Configuration

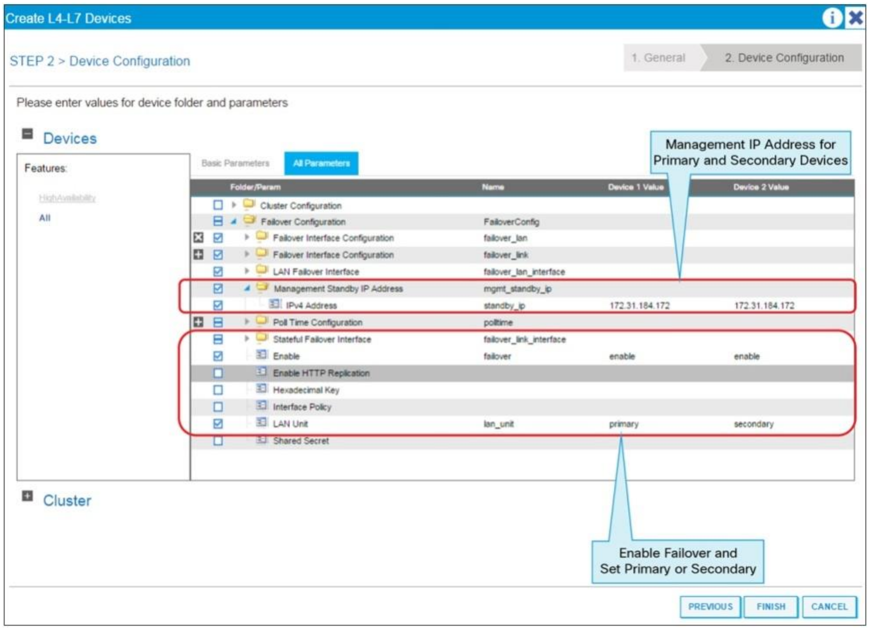


Please enter values for device folder and parameters

	Folder/Param	Name	Device 1 Value	Device 2 Value
	□ Cluster Configuration			
	⊟ Failover Configuration	FailoverConfig		
☒	☑ Failover Interface Configuration	failover_lan		
	☑ Active IPv4 Address	active_ip	10.1.2.1	10.1.2.1
	☑ Interface Name	interface_name	failover-lan	failover-lan
	☑ Netmask	netmask	255.255.255.0	255.255.255.0
	☑ Standby IPv4 Address	standby_ip	10.1.2.2	10.1.2.2
⊞	☑ Failover Interface Configuration	failover_link		
	☑ LAN Failover Interface	failover_lan_interface		
	☑ Interface Name	interface_name	failover-lan	failover-lan
	☑ Physical Interface	interface	GigabitEthernet0/6	GigabitEthernet0/6
	□ Management Standby IP Address			
⊞	⊟ Poll Time Configuration	polltime		
	□ Hold Time			
	□ Hold Time Units			
	☑ Interval	interval_value	3	3
	□ Interval Units			

You also must configure a secondary management IP address. Otherwise, the APIC can’t access the secondary ASA (Figure 56).

Figure 56. Secondary Management IP Address Configuration



Please enter values for device folder and parameters

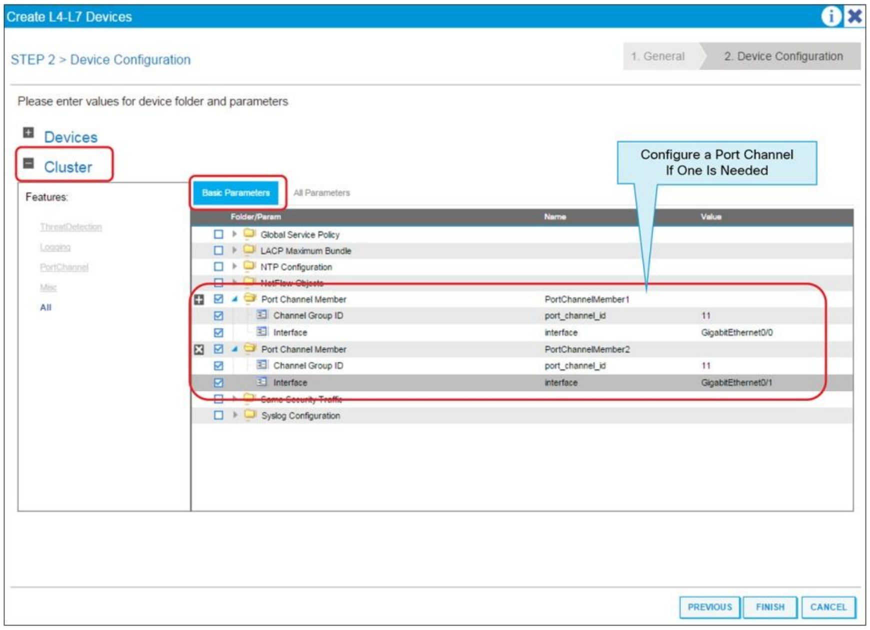
Folder/Param	Name	Device 1 Value	Device 2 Value
□ Cluster Configuration			
Failover Configuration	FailoverConfig		
☑ Failover Interface Configuration	failover_lan		
☑ Failover Interface Configuration	failover_link		
☑ LAN Failover Interface	failover_lan_interface		
☑ Management Standby IP Address	mgmt_standby_ip		
☑ IPv4 Address	standby_ip	172.31.184.172	172.31.184.172
Poll Time Configuration	polltime		
Stateful Failover Interface	failover_link_interface		
☑ Enable	failover	enable	enable
□ Enable HTTP Replication			
□ Hexadecimal Key			
□ Interface Policy			
☑ LAN Unit	lan_unit	primary	secondary
□ Shared Secret			

Management IP Address for Primary and Secondary Devices

Enable Failover and Set Primary or Secondary

You can also configure a port channel (Figure 57). This configuration is optional.

Figure 57. Port-Channel Configuration



Please enter values for device folder and parameters

Folder/Param	Name	Value
□ Global Service Policy		
□ LACP Maximum Bundle		
□ NTP Configuration		
□ NetFlow Objects		
☑ Port Channel Member	PortChannelMember1	
☑ Channel Group ID	port_channel_id	11
☑ Interface	interface	GigabitEthernet0/0
☑ Port Channel Member	PortChannelMember2	
☑ Channel Group ID	port_channel_id	11
☑ Interface	interface	GigabitEthernet0/1
□ Same Security Traffic		
□ Syslog Configuration		

Configure a Port Channel If One Is Needed

When you successfully complete the configuration, you can see failover configuration on both ASA devices.

Primary Cisco ASA Configuration (Performed by Cisco APIC)

```
interface GigabitEthernet0/0
 channel-group 11 mode active
!
```

```
interface GigabitEthernet0/1
 channel-group 11 mode active

interface GigabitEthernet0/6
 description LAN Failover Interface
!
interface GigabitEthernet0/7
 description STATE Failover Interface
!

failover
failover lan unit primary
failover lan interface failover-lan GigabitEthernet0/6
failover polltime unit 3 holdtime 9
failover link failover-link GigabitEthernet0/7
failover interface ip failover-lan 10.1.2.1 255.255.255.0 standby 10.1.2.2
failover interface ip failover-link 10.1.1.1 255.255.255.0 standby 10.1.1.2

interface Management0/0
 management-only
 nameif management
 security-level 100
 ip address 172.31.184.171 255.255.252.0 standby 172.31.184.172
```

Secondary Cisco ASA Configuration (Performed by Cisco APIC)

```
interface GigabitEthernet0/0
 channel-group 11 mode active
!
interface GigabitEthernet0/1
 channel-group 11 mode active

interface GigabitEthernet0/6
 description LAN Failover Interface
!
interface GigabitEthernet0/7
 description STATE Failover Interface
!

failover
failover lan unit secondary
failover lan interface failover-lan GigabitEthernet0/6
failover polltime unit 3 holdtime 9
failover link failover-link GigabitEthernet0/7
failover interface ip failover-lan 10.1.2.1 255.255.255.0 standby 10.1.2.2
failover interface ip failover-link 10.1.1.1 255.255.255.0 standby 10.1.1.2
```

```
interface Management0/0
 management-only
 nameif management
 security-level 100
 ip address 172.31.184.171 255.255.252.0 standby 172.31.184.172
```

Failover Status (Primary)

```
ASA5525X-1# show failover
Failover On
Failover unit Primary
Failover LAN Interface: failover-lan GigabitEthernet0/6 (up)
Reconnect timeout 0:00:00
Unit Poll frequency 3 seconds, holdtime 9 seconds
Interface Poll frequency 5 seconds, holdtime 25 seconds
Interface Policy 1
Monitored Interfaces 1 of 216 maximum
MAC Address Move Notification Interval not set
Version: Ours 9.5(2), Mate 9.5(2)
Last Failover at: 14:37:06 UTC Feb 5 2016
        This host: Primary - Active
                Active time: 8781 (sec)
                slot 0: ASA5525 hw/sw rev (1.0/9.5(2)) status (Up Sys)
                  admin Interface management (172.31.184.171): Normal (Monitored)
                slot 1: SFR5525 hw/sw rev (N/A/5.3.1-152) status (Up/Up)
                  ASA FirePOWER, 5.3.1-152, Up, (Monitored)
        Other host: Secondary - Standby Ready
                Active time: 0 (sec)
                slot 0: ASA5525 hw/sw rev (1.0/9.5(2)) status (Up Sys)
                  admin Interface management (172.31.184.172): Normal (Monitored)
                slot 1: SFR5525 hw/sw rev (N/A/5.3.1-152) status (Up/Up)
                  ASA FirePOWER, 5.3.1-152, Up, (Monitored)
<snip>
```

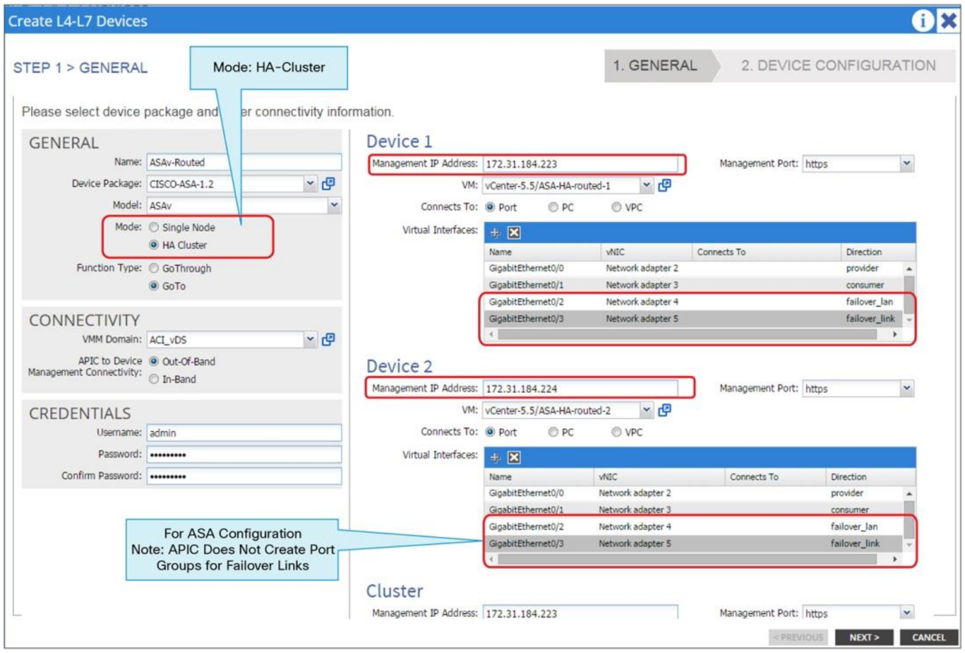
Failover Status (Secondary)

```
ASA5525X-1(config)# show failover
Failover On
Failover unit Secondary
Failover LAN Interface: failover-lan GigabitEthernet0/6 (up)
Reconnect timeout 0:00:00
Unit Poll frequency 3 seconds, holdtime 9 seconds
Interface Poll frequency 5 seconds, holdtime 25 seconds
Interface Policy 1
Monitored Interfaces 1 of 216 maximum
MAC Address Move Notification Interval not set
Version: Ours 9.5(2), Mate 9.5(2)
Last Failover at: 14:16:36 UTC Feb 5 2016
        This host: Secondary - Standby Ready
                Active time: 0 (sec)
                slot 0: ASA5525 hw/sw rev (1.0/9.5(2)) status (Up Sys)
                  admin Interface management (172.31.184.172): Normal (Monitored)
                slot 1: SFR5525 hw/sw rev (N/A/5.3.1-152) status (Up/Up)
                  ASA FirePOWER, 5.3.1-152, Up, (Monitored)
        Other host: Primary - Active
                Active time: 8700 (sec)
                slot 0: ASA5525 hw/sw rev (1.0/9.5(2)) status (Up Sys)
                  admin Interface management (172.31.184.171): Normal (Monitored)
                slot 1: SFR5525 hw/sw rev (N/A/5.3.1-152) status (Up/Up)
                  ASA FirePOWER, 5.3.1-152, Up, (Monitored)
<snip>
```

Deploying Redundant Virtual Appliances

Regardless of whether you are using in-band or out-of-band failover traffic, you need to create a port group for failover traffic and attach the vNIC to the port group. The device interface and cluster interface for failover traffic should be configured in the L4-L7 device (Figures 58 and 59).

Figure 58. L4-L7 Device Configuration



Mode: HA-Cluster

Please select device package and [...]er connectivity information.

GENERAL

- Name: ASAv-Routed
- Device Package: CISCO-ASA-1.2
- Model: ASAv
- Mode: ○ Single Node ● HA Cluster
- Function Type: ○ GoThrough ● GoTo

CONNECTIVITY

- VMM Domain: ACI_vDS
- APIC to Device Management Connectivity: ● Out-Of-Band ○ In-Band

CREDENTIALS

- Username: admin
- Password: •••••••••
- Confirm Password: •••••••••

For ASA Configuration
Note: APIC Does Not Create Port Groups for Failover Links

Device 1

- Management IP Address: 172.31.184.223
- Management Port: https
- VM: vCenter-5.5/ASA-HA-routed-1
- Connects To: ● Port ○ PC ○ VPC
- Virtual Interfaces:

Name	vNIC	Connects To	Direction
GigabitEthernet0/0	Network adapter 2		provider
GigabitEthernet0/1	Network adapter 3		consumer
GigabitEthernet0/2	Network adapter 4		failover_lan
GigabitEthernet0/3	Network adapter 5		failover_link

Device 2

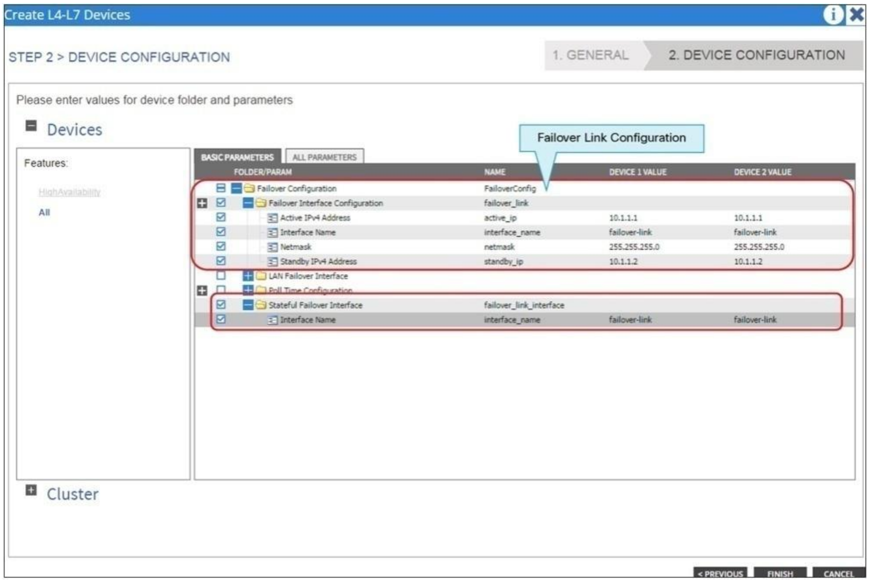
- Management IP Address: 172.31.184.224
- Management Port: https
- VM: vCenter-5.5/ASA-HA-routed-2
- Connects To: ● Port ○ PC ○ VPC
- Virtual Interfaces:

Name	vNIC	Connects To	Direction
GigabitEthernet0/0	Network adapter 2		provider
GigabitEthernet0/1	Network adapter 3		consumer
GigabitEthernet0/2	Network adapter 4		failover_lan
GigabitEthernet0/3	Network adapter 5		failover_link

Cluster

- Management IP Address: 172.31.184.223
- Management Port: https

Figure 59. Stateful Failover Link Configuration



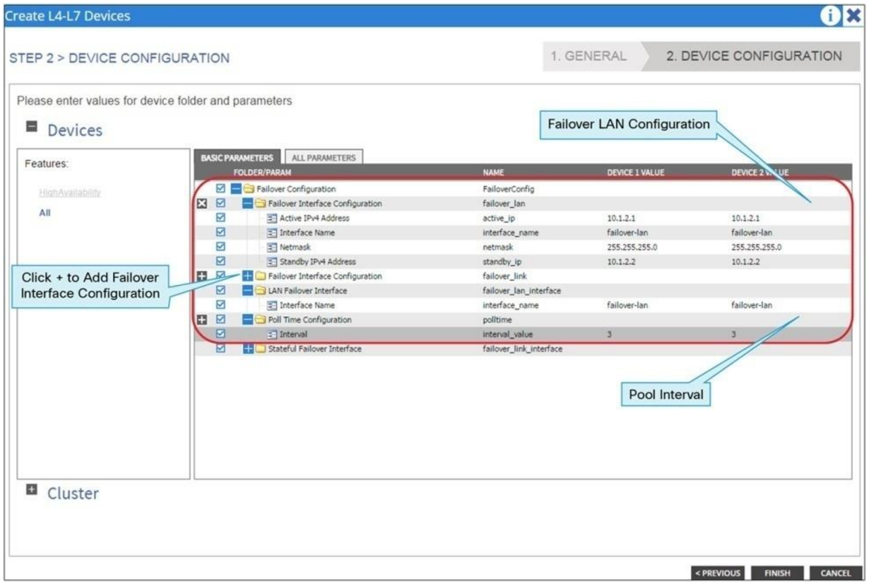
Please enter values for device folder and parameters

Failover Link Configuration

FOLDER/PARAM	NAME	DEVICE 1 VALUE	DEVICE 2 VALUE
Failover Configuration	FailoverConfig		
☑ Failover Interface Configuration	failover_link		
☑ Active IPv4 Address	active_ip	10.1.1.1	10.1.1.1
☑ Interface Name	interface_name	failover-link	failover-link
☑ Netmask	netmask	255.255.255.0	255.255.255.0
☑ Standby IPv4 Address	standby_ip	10.1.1.2	10.1.1.2
□ LAN Failover Interface			
□ Poll Time Configuration			
☑ Stateful Failover Interface	failover_link_interface		
☑ Interface Name	interface_name	failover-link	failover-link

For a virtual appliance, you don’t need to specify the interface here because it is defined in the L4-L7 device configuration (Figure 60).

Figure 60. Failover Link Configuration



FOLDER/PARAM	NAME	DEVICE 1 VALUE	DEVICE 2 VALUE
☑ Failover Configuration	FailoverConfig		
☒ ☑ Failover Interface Configuration	failover_lan		
☑ Active IPv4 Address	active_ip	10.1.2.1	10.1.2.1
☑ Interface Name	interface_name	failover-lan	failover-lan
☑ Netmask	netmask	255.255.255.0	255.255.255.0
☑ Standby IPv4 Address	standby_ip	10.1.2.2	10.1.2.2
☑ Failover Interface Configuration	failover_link		
☑ LAN Failover Interface	failover_lan_interface		
☑ Interface Name	interface_name	failover-lan	failover-lan
☑ Poll Time Configuration	polltime		
☑ Interval	interval_value	3	3
☑ Stateful Failover Interface	failover_link_interface		

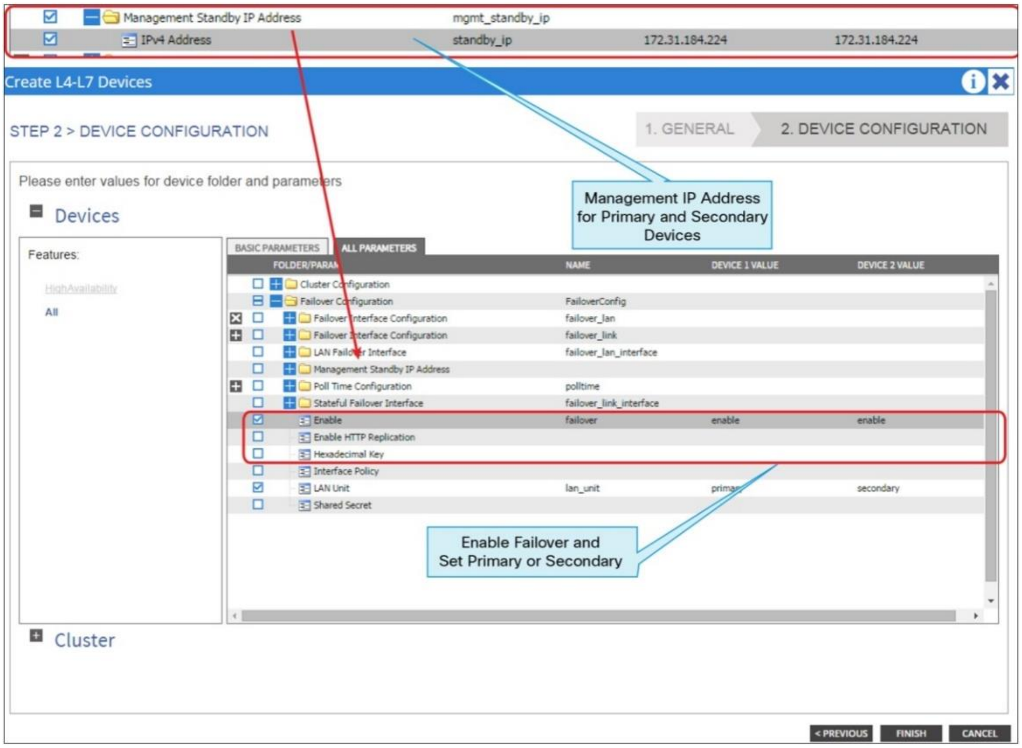
Failover LAN Configuration

Click + to Add Failover Interface Configuration

Pool Interval

You must configure the secondary management IP address. Otherwise, the APIC can’t access the secondary ASA device (Figure 61).

Figure 61. Secondary Management IP Address Configuration



☑ Management Standby IP Address	mgmt_standby_ip		
☑ IPv4 Address	standby_ip	172.31.184.224	172.31.184.224

FOLDER/PARAM	NAME	DEVICE 1 VALUE	DEVICE 2 VALUE
□ Cluster Configuration			
Failover Configuration	FailoverConfig		
☒ □ Failover Interface Configuration	failover_lan		
□ Failover Interface Configuration	failover_link		
□ LAN Failover Interface	failover_lan_interface		
□ Management Standby IP Address			
□ Poll Time Configuration	polltime		
□ Stateful Failover Interface	failover_link_interface		
☑ Enable	failover	enable	enable
□ Enable HTTP Replication			
□ Hexadecimal Key			
□ Interface Policy			
☑ LAN Unit	lan_unit	primary	secondary
□ Shared Secret			

Management IP Address for Primary and Secondary Devices

Enable Failover and Set Primary or Secondary

After you’ve completed the configuration successfully, you can see the failover configuration on both Cisco Adaptive Security Virtual Appliance (ASAv) devices.

Primary Cisco ASA Configuration (Performed by Cisco APIC)

```
interface GigabitEthernet0/2
 description LAN Failover Interface
!
interface GigabitEthernet0/3
 description STATE Failover Interface
!

interface Management0/0
 management-only
 nameif management
 security-level 0
 ip address 172.31.184.223 255.255.252.0 standby 172.31.184.224

failover
failover lan unit primary
failover lan interface failover-lan GigabitEthernet0/2
failover polltime unit 3 holdtime 9
failover link failover-link GigabitEthernet0/3
failover interface ip failover-lan 10.1.2.1 255.255.255.0 standby 10.1.2.2
failover interface ip failover-link 10.1.1.1 255.255.255.0 standby 10.1.1.2
```

Secondary Cisco ASA Configuration (Performed by Cisco APIC)

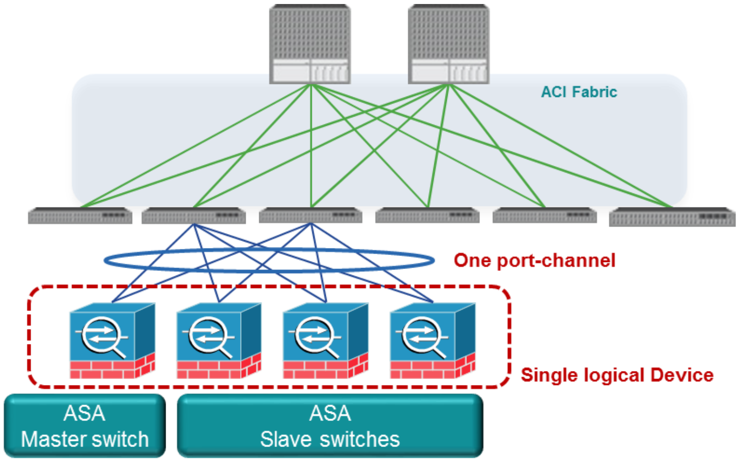
```
interface GigabitEthernet0/2
 description LAN Failover Interface
!
interface GigabitEthernet0/3
 description STATE Failover Interface
!

interface Management0/0
 management-only
 nameif management
 security-level 0
 ip address 172.31.184.223 255.255.252.0 standby 172.31.184.224

failover
failover lan unit secondary
failover lan interface failover-lan GigabitEthernet0/2
failover polltime unit 3 holdtime 9
failover link failover-link GigabitEthernet0/3
failover interface ip failover-lan 10.1.2.1 255.255.255.0 standby 10.1.2.2
failover interface ip failover-link 10.1.1.1 255.255.255.0 standby 10.1.1.2
```

Deploying Clustering for Physical Appliances (Cisco ASA Cluster)

Cisco ASA clustering allows you to group multiple ASA nodes together as a single logical device to provide high availability and scalability. ASA clustering also can be integrated with Cisco ACI. ASA clustering has two modes: spanned EtherChannel mode (recommended) and individual interface mode. This document focuses on the spanned EtherChannel mode because it is the recommended choice.

One member of the cluster is elected as the primary switch. The primary switch handles the configuration, which is replicated on the secondary switches. In spanned EtherChannel mode, all ASA devices in the cluster use the same port channel, and traffic is load-balanced as part of the port-channel operation. From the perspective of the Cisco ACI fabric, the cluster is a single logical device connected to the Cisco ACI fabric through one port channel (Figure 62).

Figure 62. Cisco ASA Clustering



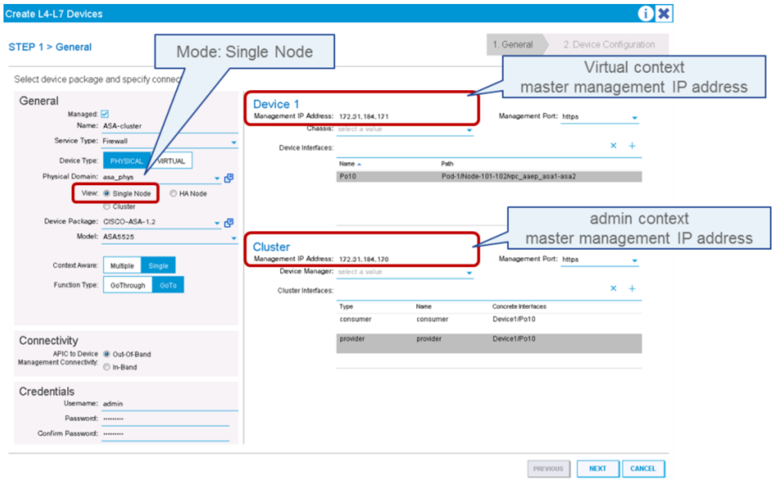
For more information about ASA clustering, see the Cisco ASA cluster section in the Cisco ASA configuration guide at https://www.cisco.com/c/en/us/td/docs/security/asa/asa97/configuration/general/asa-97-general-config/ha-cluster.html.

Note: As of this writing, for spanned EtherChannel mode, ASA devices in the same ASA cluster must be connected to the Cisco ACI fabric through the same vPC or port channel. The reason for this requirement is that Cisco ACI fabric will learn the same endpoint from different port-channel interfaces, which may cause endpoint flapping if you use different port channels. Thus, ASA clustering across pods is not supported. The Cisco ACI fabric capabilities will be enhanced handle this situation in Q2CY18.

For L4-L7 device configuration, note that Cisco ASA clustering is supported on physical ASA devices only, not virtual ASA devices. As in the physical appliance example in the previous section, you need to create a virtual context and add it as an L4-L7 device on the APIC. However, you need to use the Single Node mode, because from the perspective of Cisco ACI, the cluster is one big logical device. The APIC needs to communicate with the primary switch to push the configuration to the ASA devices in the cluster.

In a L4-L7 device configuration, the device management address is the primary management IP address in the virtual context. The cluster management IP address is the primary management IP address in the administration context (Figures 63 and 64).

Figure 63. L4-L7 Device Configuration



Create L4-L7 Devices

STEP 1 > General

1. General | 2. Device Configuration

Select device package and specify connec

Mode: Single Node

Virtual context master management IP address

admin context master management IP address

General

Managed: ☑
Name: ASA-cluster
Service Type: Firewall
Device Type: PHYSICAL | VIRTUAL
Physical Domain: asa_phys
View: ● Single Node ○ HA Node ○ Cluster
Device Package: CISCO-ASA-1.2
Model: ASA5525
Context Aware: Multiple | Single
Function Type: GoThrough | GoTo

Connectivity

APIC to Device Management Connectivity: ● Out-Of-Band ○ In-Band

Credentials

Username: admin
Password: ••••••••
Confirm Password: ••••••••

Device 1

Management IP Address: 172.31.184.171
Management Port: https
Chassis: select a value
Device Interfaces:

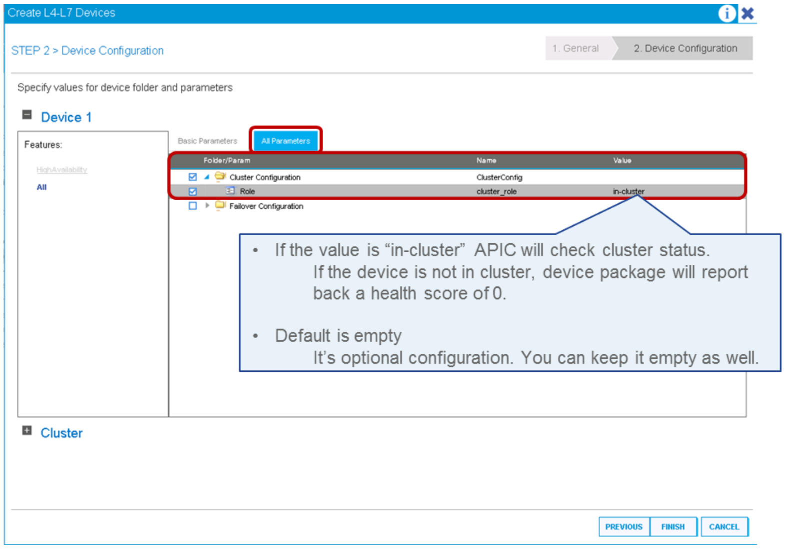
Name	Path
Po10	Pod-1/Node-101-102/vpc_aaep_asa1-asa2

Cluster

Management IP Address: 172.31.184.170
Management Port: https
Device Manager: select a value
Cluster Interfaces:

Type	Name	Concrete Interfaces
consumer	consumer	Device1/Po10
provider	provider	Device1/Po10

Figure 64. L4-L7 Device Configuration (Optional)



Create L4-L7 Devices

STEP 2 > Device Configuration

1. General | 2. Device Configuration

Specify values for device folder and parameters

Device 1

Features:
HighAvailability
All

Basic Parameters | All Parameters

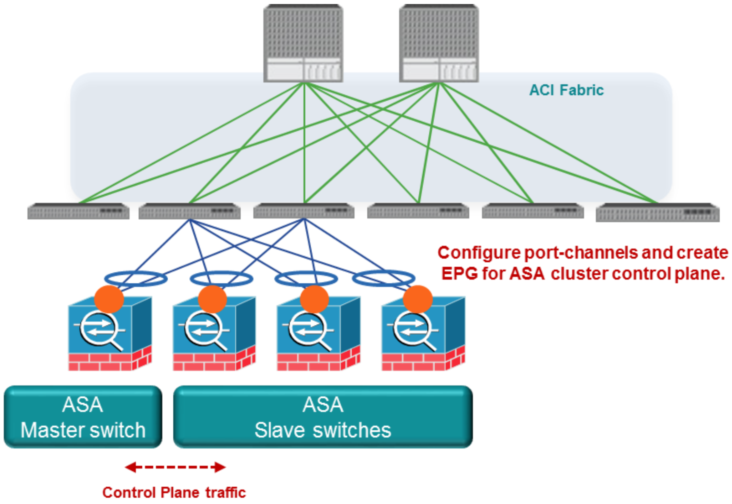
Folder/Param	Name	Value
☑ Cluster Configuration	ClusterConfig	
☑ Role	cluster_role	in-cluster
□ Failover Configuration		

- If the value is "in-cluster" APIC will check cluster status.
  If the device is not in cluster, device package will report back a health score of 0.
- Default is empty
  It's optional configuration. You can keep it empty as well.

Cluster

Note that ASA clustering must be configured beforehand. Clustering configuration is not supported during L4-L7 device creation on the APIC using a device package. To set up ASA clustering, you need separate port channels for the cluster control plane in addition to the spanned EtherChannel for cluster data plane (Figure 65).

Figure 65. Port Channels for Cluster Control Plane


ACI Fabric
Configure port-channels and create EPG for ASA cluster control plane.
ASA Master switch
ASA Slave switches
Control Plane traffic

Design for Sharing L4-L7 Appliances

Some L4-L7 appliances have multitenant functions. These functions differ by vendor. This section describes multitenant design using Cisco ASA and F5 BIG-IP. It also describes how to share an L4-L7 device among different tenants and use multiple service graph rendering.

Multiple Tenants: Using a Cisco ASA Physical Appliance

The ASA virtual context capability provides multiple service appliance instances on a physical appliance. Each virtual context has a different configuration space, a different management IP address, different credentials, etc. The Cisco ACI service graph treats each virtual context as a concrete device (L4-L7 device on the APIC), so you can share one ASA physical device across multiple tenants and use multiple service graph rendering (Figures 66 and 67).

Figure 66. Cisco ASA Virtual Context

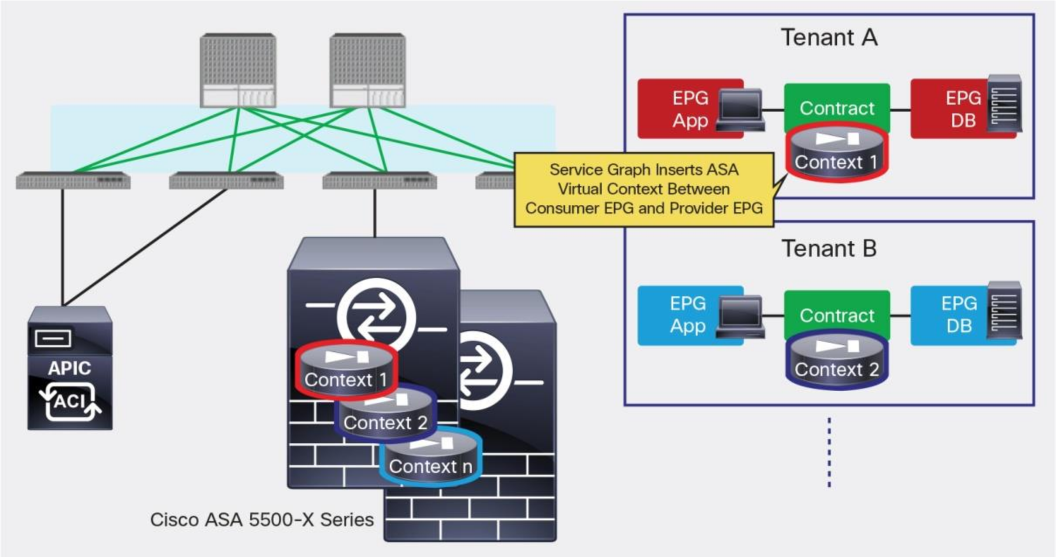
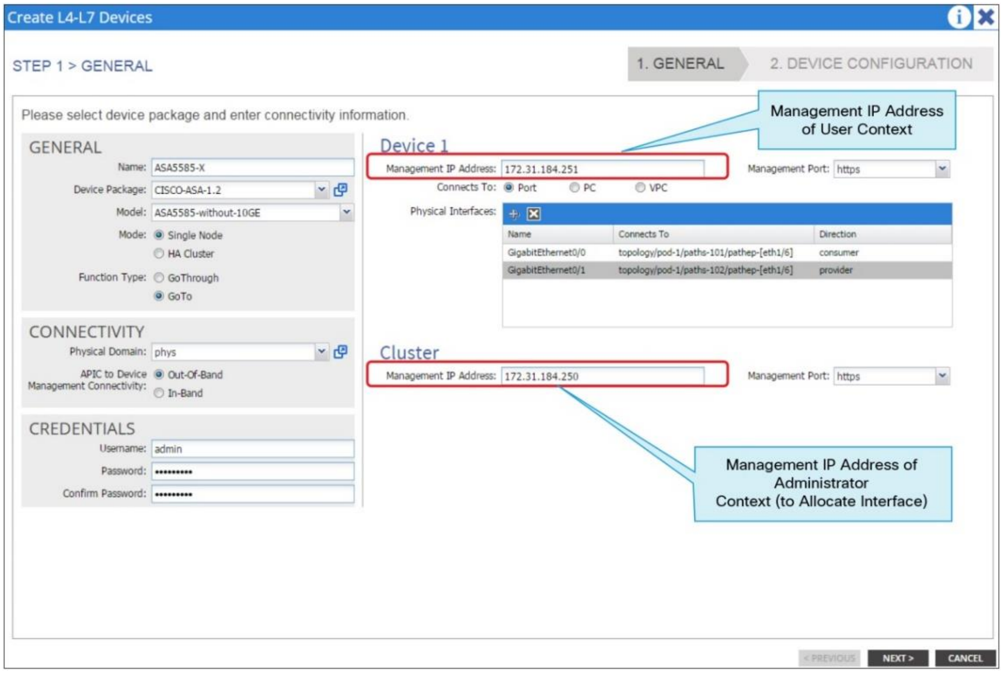


Figure 67. L4-L7 Device Configuration on Cisco APIC



Create L4-L7 Devices

STEP 1 > GENERAL

1. GENERAL | 2. DEVICE CONFIGURATION

Please select device package and enter connectivity information.

GENERAL

Name: ASA5585-X

Device Package: CISCO-ASA-1.2

Model: ASA5585-without-10GE

Mode: ● Single Node ○ HA Cluster

Function Type: ○ GoThrough ● GoTo

CONNECTIVITY

Physical Domain: phys

APIC to Device Management Connectivity: ● Out-Of-Band ○ In-Band

CREDENTIALS

Username: admin

Password: ••••••••••

Confirm Password: ••••••••••

Device 1

Management IP Address: 172.31.184.251

Management Port: https

Connects To: ● Port ○ PC ○ VPC

Physical Interfaces:

Name	Connects To	Direction
GigabitEthernet0/0	topology/pod-1/paths-101/pathep-[eth1/6]	consumer
GigabitEthernet0/1	topology/pod-1/paths-102/pathep-[eth1/6]	provider

Cluster

Management IP Address: 172.31.184.250

Management Port: https

Management IP Address of User Context

Management IP Address of Administrator Context (to Allocate Interface)

The cluster IP address should be the ASA admin context IP address, so the APIC can allocate the interface in the system context and configure it in the virtual context during service graph rendering.

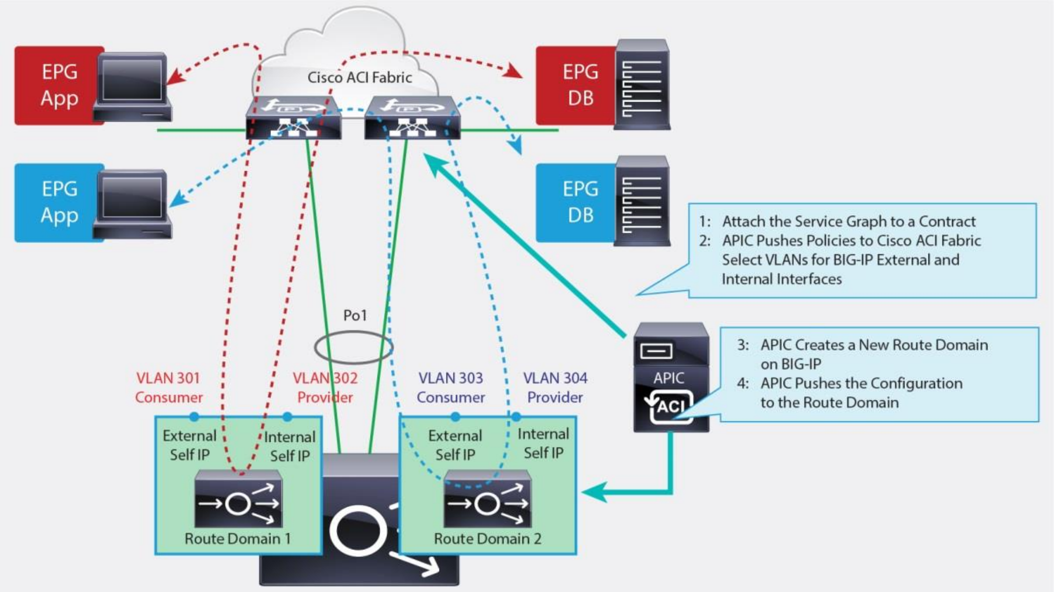
Note: As of this writing, the APIC doesn’t manage ASA virtual context creation, so you need to create the virtual context beforehand.

Multiple Tenants: Using an F5 BIG-IP Physical Appliance

F5 BIG-IP Local Traffic Manager (LTM) has a route domain capability similar to VRF. It provides routing table isolation, but all partitions are in the same service device and share the same management IP address, which is different from the ASA multi-context capability. The Cisco ACI service graph treats a BIG-IP LTM physical appliance, which hosts multiple partitions, as one concrete device. It can be exported to multiple tenants and can be used in multiple service graph rendering. During service graph rendering, the APIC creates new partitions automatically, so you don’t have to create partitions and add concrete devices beforehand (Figure 68).

Note: Some BIG-IP LTM platforms support virtual clustered multiprocessing (vCMP), which is similar to the ASA virtual context. vCMP allows you to run multiple instances of the BIG-IP software on a single hardware platform. For details, please see the F5 documentation.

Figure 68. F5 BIG-IP Multitenant Design



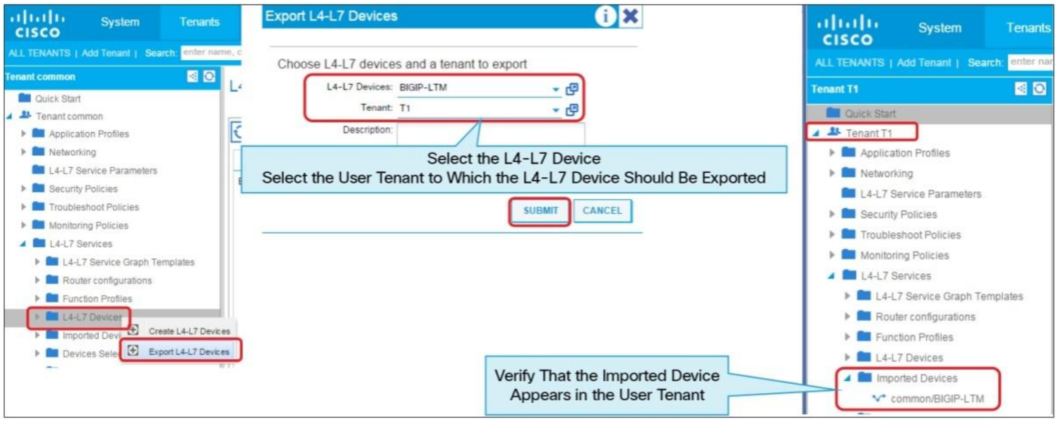
1: Attach the Service Graph to a Contract
2: APIC Pushes Policies to Cisco ACI Fabric Select VLANs for BIG-IP External and Internal Interfaces

3: APIC Creates a New Route Domain on BIG-IP
4: APIC Pushes the Configuration to the Route Domain

Sharing L4-L7 Devices with Another Tenant

L4-L7 device can't be referenced from other tenants. If you want to share an L4-L7 device with other tenants, you need to export the L4-L7 device to other tenants. It will appear as an imported device in the other tenants (Figure 69). We always need export even L4-L7 device is defined in common.

Figure 69. L4-L7 Device Configuration on Cisco APIC



Export L4-L7 Devices

Choose L4-L7 devices and a tenant to export

L4-L7 Devices: BIGIP-LTM

Tenant: T1

Description:

Select the L4-L7 Device
Select the User Tenant to Which the L4-L7 Device Should Be Exported

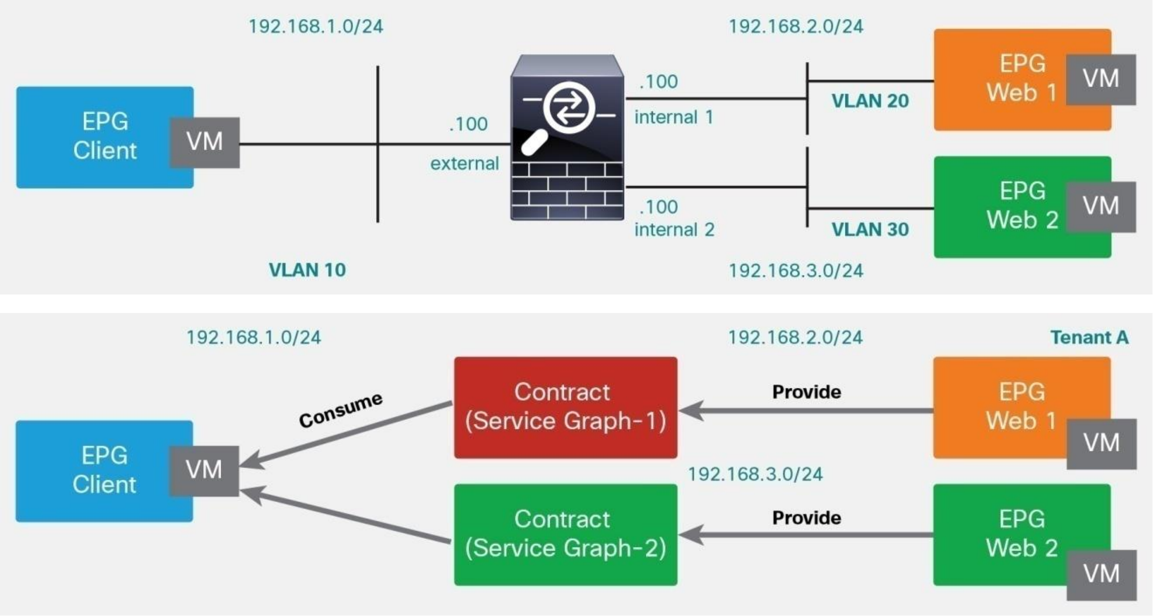
common/BIGIP-LTM

Verify That the Imported Device Appears in the User Tenant

Using an L4-L7 Device with Multiple Service Graphs

Each service graph rendering uses one or two connectors, for the consumer and the provider. However, in an actual deployment, the service appliance may have two or more interfaces to connect multiple servers in different zones, as shown in Figure 70. This section describes how to achieve this design with a service graph.

Figure 70. Using an L4-L7 Device with Multiple Service Graphs

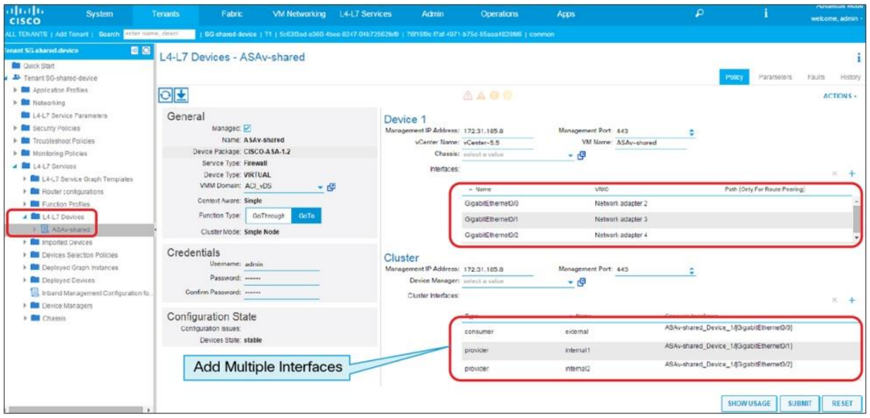


The main point is that you can create multiple cluster interfaces on a concrete device and then specify which cluster interface defined in the L4-L7 device will be used for the connector in the device selection policy. This cluster interface can be shared by using multiple service graph rendering.

Example 1: Share Consumer Interface (Virtual Appliance)

The example in Figure 70 has three EPGs, two service graphs, and one concrete virtual service device. You create three cluster interfaces in the L4-L7 device (Figure 71).

Figure 71. Cluster Interface (Virtual Appliance)



L4-L7 Devices - ASAv-shared

General

Managed: ☑
Name: ASAv-shared
Device Package: CISCO-ASA-1.2
Service Type: Firewall
Device Type: VIRTUAL
VMM Domain: ACI_vDS
Context Aware: Single
Function Type: GoThrough [✓ GoTo]
Cluster Mode: Single Node

Credentials

Username: admin
Password: ••••••••
Confirm Password: ••••••••

Configuration State

Configuration Issues:
Devices State: stable

Add Multiple Interfaces

Device 1

Management IP Address: 172.31.185.8
Management Port: 443
vCenter Name: vCenter-5.5
VM Name: ASAv-shared
Chassis: select a value
Interfaces:

Name	VNIC	Path (Only For Route Peering)
GigabitEthernet0/0	Network adapter 2	
GigabitEthernet0/1	Network adapter 3	
GigabitEthernet0/2	Network adapter 4	

Cluster

Management IP Address: 172.31.185.8
Management Port: 443
Device Manager: select a value
Cluster Interfaces:

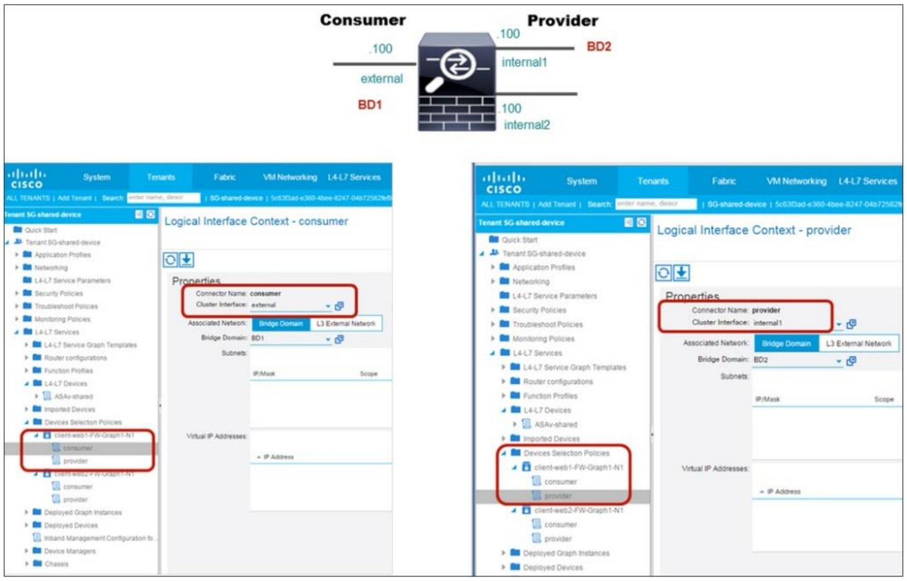
Type	Name	Concrete Interfaces
consumer	external	ASAv-shared_Device_1/[GigabitEthernet0/0]
provider	internal1	ASAv-shared_Device_1/[GigabitEthernet0/1]
provider	internal2	ASAv-shared_Device_1/[GigabitEthernet0/2]

In the device selection policy, you specify which cluster interface defined in the L4-L7 device will be used for the connector. This cluster interface can be shared by multiple service graph rendering (Figures 72 and 73). In this example, cluster interface “external” is used twice:

- Service-Graph1 uses cluster interface “external” as the consumer connector and “internal1” as the provider connector.

- Service-Graph2 uses cluster interface “external” as the consumer connector and “internal2” as the provider connector.

Figure 72. Device Selection Policy for Service-Graph1 (Virtual Appliance)



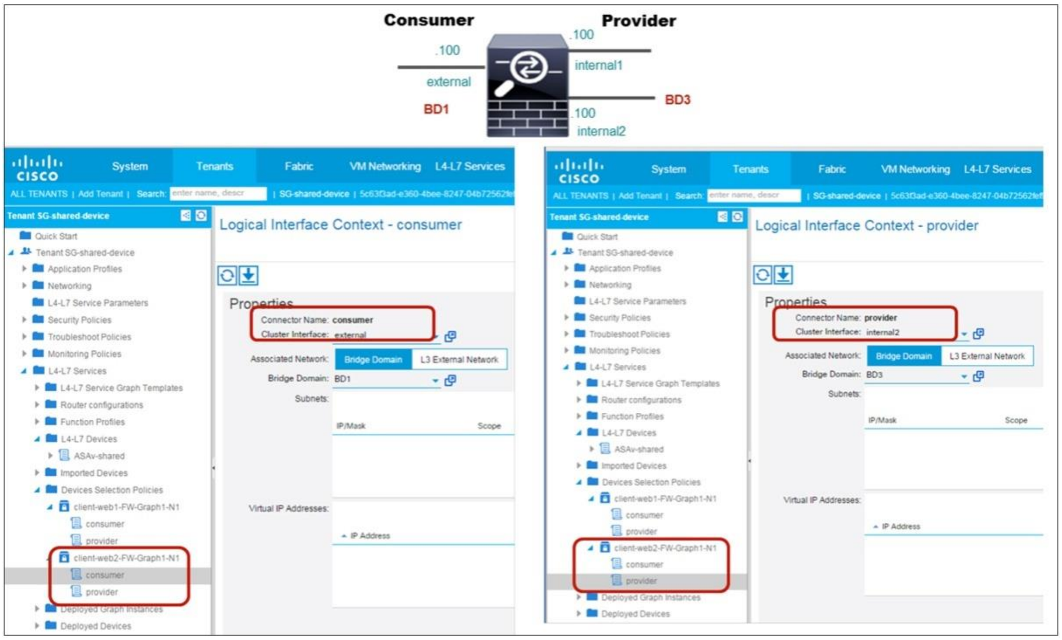
Logical Interface Context - consumer

Connector Name: consumer
Cluster Interface: external
Associated Network: Bridge Domain
Bridge Domain: BD1

Logical Interface Context - provider

Connector Name: provider
Cluster Interface: internal1
Associated Network: Bridge Domain
Bridge Domain: BD2

Figure 73. Device Selection Policy for Service-Graph2 (Virtual Appliance)



Logical Interface Context - consumer

Connector Name: consumer
Cluster Interface: external
Associated Network: Bridge Domain
Bridge Domain: BD1

Logical Interface Context - provider

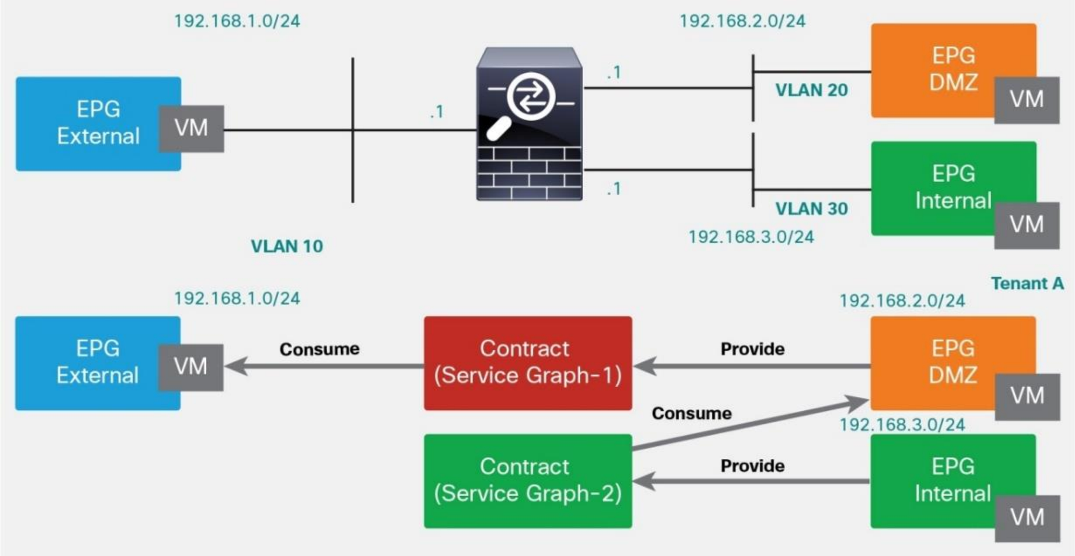
Connector Name: provider
Cluster Interface: internal2
Associated Network: Bridge Domain
Bridge Domain: BD3

Note: As of this writing, the VMware port group created by the APIC doesn’t support trunk mode, so if the bridge domain of the connector is different for each service graph rendering, you need to a separate interface on the virtual appliance.

Example 2: DMZ (Virtual Appliance)

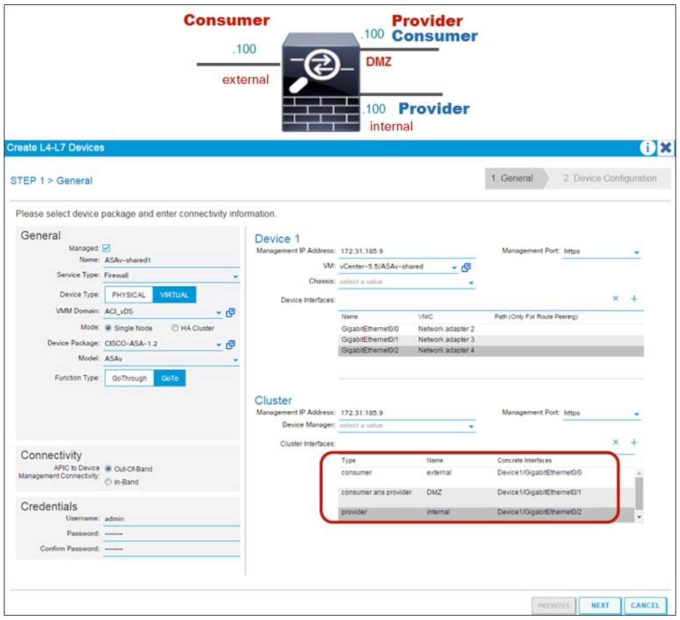
The example in Figure 74 has three EPGs, two service graphs, and one concrete virtual service device. You create three cluster interfaces in the L4-L7 device.

Figure 74. Cluster Interface (Virtual Appliance)



The ASA DMZ interface (192.168.2.1) is the consumer and also the provider, so you use the “consumer and provider” options for the cluster interface (Figure 75).

Figure 75. Configuring the Options for the Cluster Interface



STEP 1 > General

Please select device package and enter connectivity information.

General

Managed: ☑

Name: ASAv-shared1

Service Type: Firewall

Device Type: PHYSICAL [✓ VIRTUAL]

VMM Domain: ACI_vDS

Mode: ● Single Node ○ HA Cluster

Device Package: CISCO-ASA-1.2

Model: ASAv

Function Type: GoThrough [✓ GoTo]

Connectivity

APIC to Device Management Connectivity: ● Out-Of-Band ○ In-Band

Credentials

Username: admin

Password: --------

Confirm Password: --------

Device 1

Management IP Address: 172.31.185.9

Management Port: https

VM: vCenter-5.5/ASAv-shared

Chassis: select a value

Device Interfaces:

Name	VNIC	Path (Only For Route Peering)
GigabitEthernet0/0	Network adapter 2	
GigabitEthernet0/1	Network adapter 3	
GigabitEthernet0/2	Network adapter 4	

Cluster

Management IP Address: 172.31.185.9

Management Port: https

Device Manager: select a value

Cluster Interfaces:

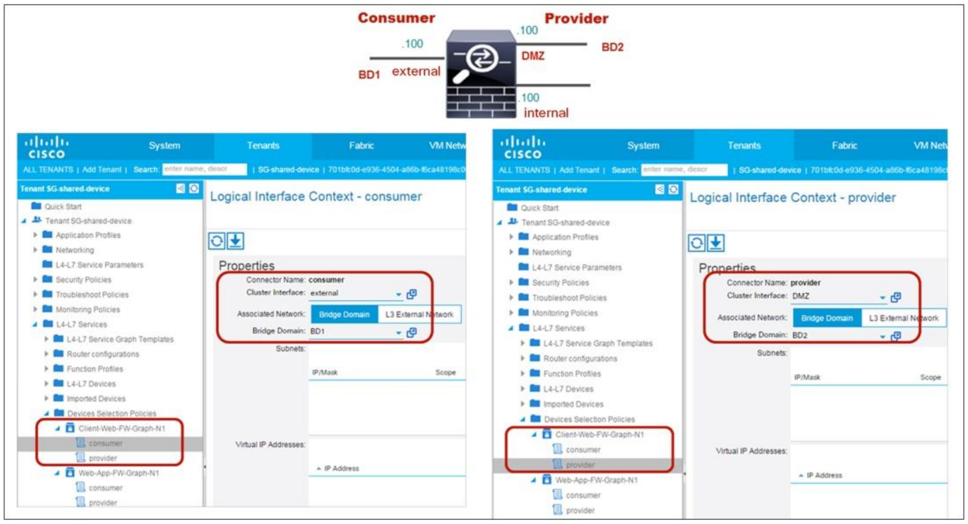
Type	Name	Concrete Interfaces
consumer	external	Device1/GigabitEthernet0/0
consumer ans provider	DMZ	Device1/GigabitEthernet0/1
provider	internal	Device1/GigabitEthernet0/2

In this example, the cluster interface “DMZ” is used twice (Figures 76 and 77):

- Service-Graph1 uses cluster interface “external” as the consumer connector and “DMZ” as the provider connector.

- Service-Graph2 uses cluster interface “DMZ” as the consumer connector and “internal” as the provider connector.

Figure 76. Device Selection Policy for Service-Graph1 (Virtual Appliance)



Logical Interface Context - consumer

Properties

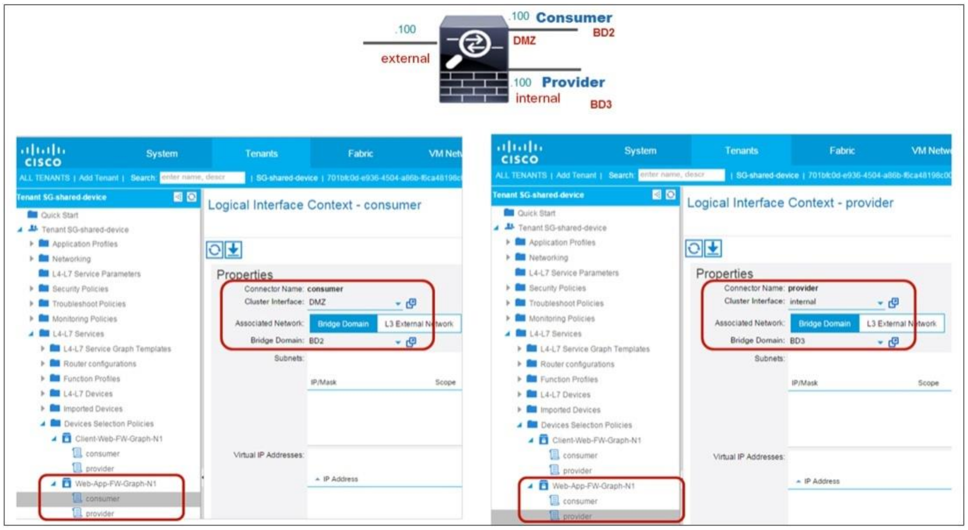
Connector Name: consumer
Cluster Interface: external
Associated Network: Bridge Domain | L3 External Network
Bridge Domain: BD1

Logical Interface Context - provider

Properties

Connector Name: provider
Cluster Interface: DMZ
Associated Network: Bridge Domain | L3 External Network
Bridge Domain: BD2

Figure 77. Device Selection Policy for Service-Graph2 (Virtual Appliance)



Logical Interface Context - consumer

Properties

Connector Name: consumer
Cluster Interface: DMZ
Associated Network: Bridge Domain | L3 External Network
Bridge Domain: BD2

Logical Interface Context - provider

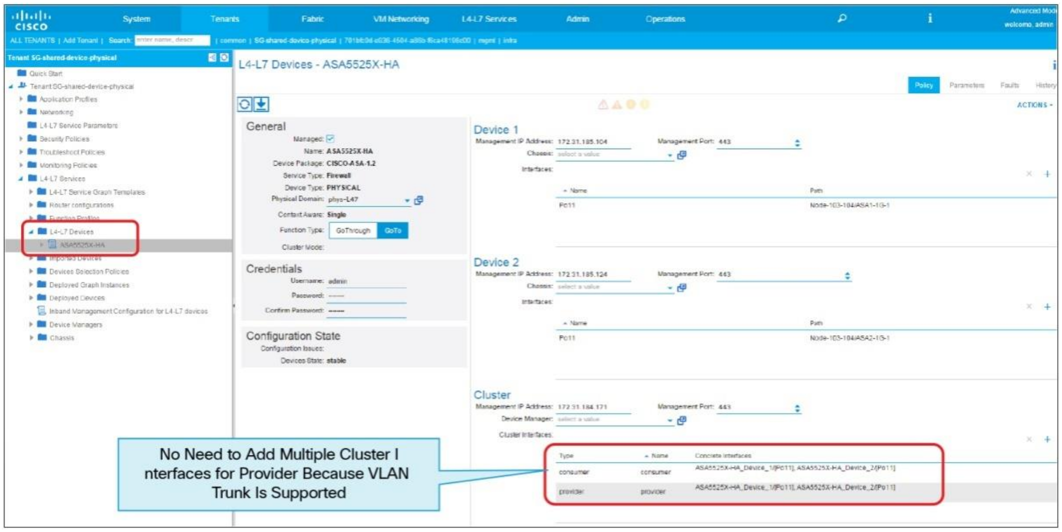
Properties

Connector Name: provider
Cluster Interface: internal
Associated Network: Bridge Domain | L3 External Network
Bridge Domain: BD3

Example 3: Share Consumer Interface (Physical Appliance)

The example in Figure 78 has three EPGs, two service graphs, and one concrete virtual service device. This example is same as Example 1, but if the L4-L7 device is physical, you don't have to add multiple cluster interfaces because you can use VLAN trunking. If the bridge domain is different for the connector, a subinterface of the ASA device will automatically be created.

Figure 78. Cluster Interface (Physical Appliance)



L4-L7 Devices - ASA5525X-HA

General

Managed: ☑
Name: ASA5525X-HA
Device Package: CISCO-ASA-1.2
Service Type: Firewall
Device Type: PHYSICAL
Physical Domain: phys-L47
Context Aware: Single
Function Type: GoThrough [✓ GoTo]
Cluster Mode:

Credentials

Username: admin
Password: ------
Confirm Password: ------

Configuration State

Configuration Issues:
Devices State: stable

Device 1

Management IP Address: 172.31.185.104 Management Port: 443
Chassis: select a value
Interfaces:

Name	Path
Po11	Node-103-104/ASA1-1G-1

Device 2

Management IP Address: 172.31.185.124 Management Port: 443
Chassis: select a value
Interfaces:

Name	Path
Po11	Node-103-104/ASA2-1G-1

Cluster

Management IP Address: 172.31.184.171 Management Port: 443
Device Manager: select a value
Cluster Interfaces:

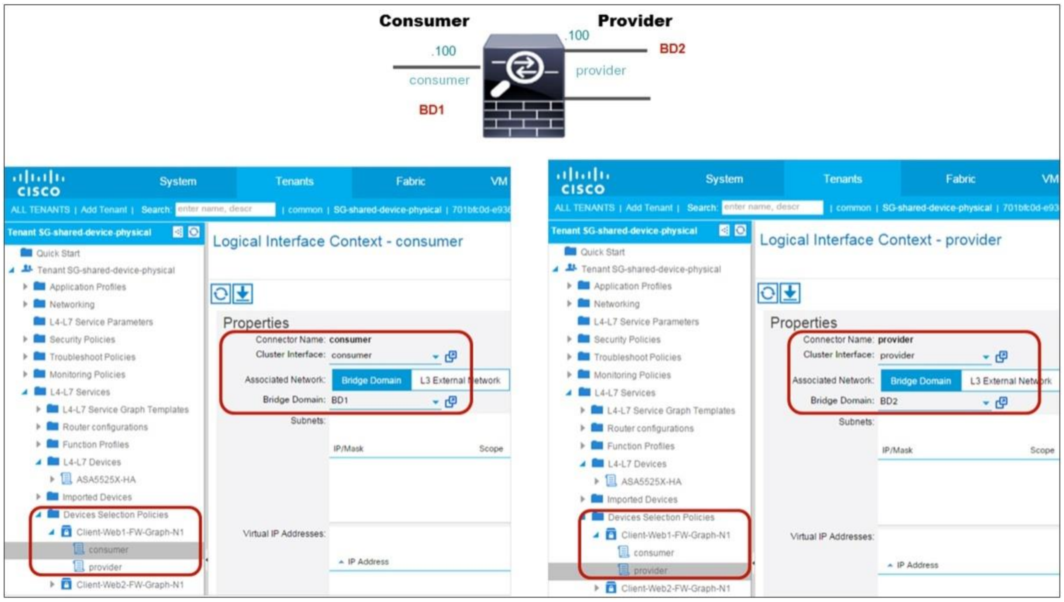
Type	Name	Concrete interfaces
consumer	consumer	ASA5525X-HA_Device_1/[Po11], ASA5525X-HA_Device_2/[Po11]
provider	provider	ASA5525X-HA_Device_1/[Po11], ASA5525X-HA_Device_2/[Po11]

No Need to Add Multiple Cluster I nterfaces for Provider Because VLAN Trunk Is Supported

In this example, you use the same cluster interface for both service graphs, but the Bridge Domain (BD) for the provider side is different, so a different subinterface is created on the service device (Figures 79 and 80):

- Service-Graph1 uses cluster interface "consumer" as the consumer connector and "provider" as the provider connector. The provider side is BD2.
- Service-Graph2 uses cluster interface "external" as the consumer connector and "internal" as the provider connector. The provider side is BD3.

Figure 79. Device Selection Policy for Service-Graph1 (Physical Appliance)



Logical Interface Context - consumer

Properties

Connector Name: **consumer**

Cluster Interface: consumer

Associated Network: Bridge Domain | L3 External Network

Bridge Domain: BD1

Subnets:

Virtual IP Addresses:

Logical Interface Context - provider

Properties

Connector Name: **provider**

Cluster Interface: provider

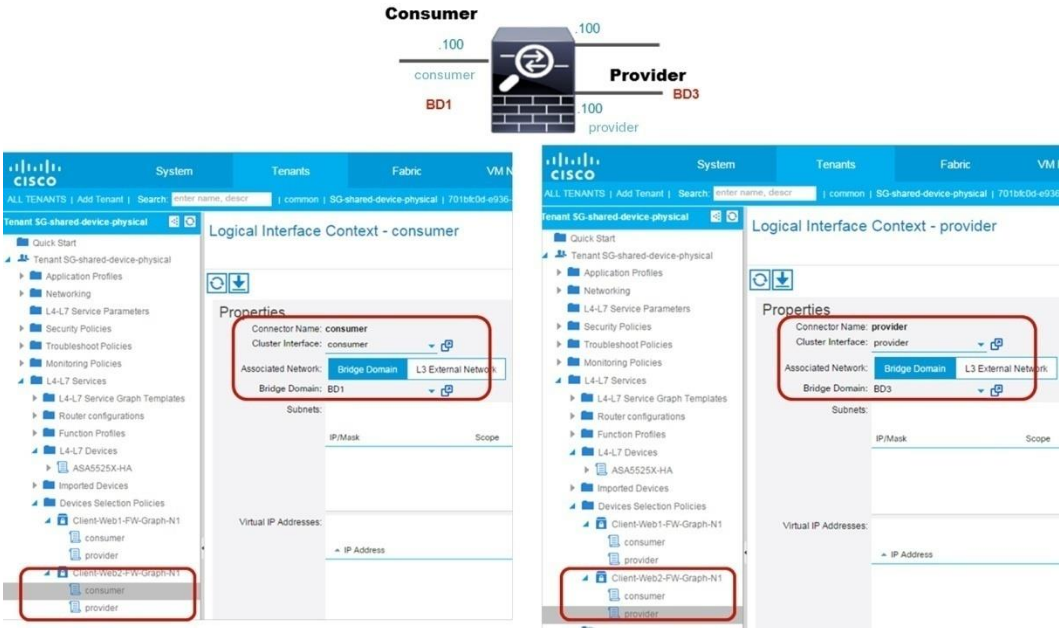
Associated Network: Bridge Domain | L3 External Network

Bridge Domain: BD2

Subnets:

Virtual IP Addresses:

Figure 80. Device Selection Policy for Service-Graph2 (Physical Appliance)



Logical Interface Context - consumer

Properties

Connector Name: **consumer**

Cluster Interface: consumer

Associated Network: Bridge Domain | L3 External Network

Bridge Domain: BD1

Subnets:

Virtual IP Addresses:

Logical Interface Context - provider

Properties

Connector Name: **provider**

Cluster Interface: provider

Associated Network: Bridge Domain | L3 External Network

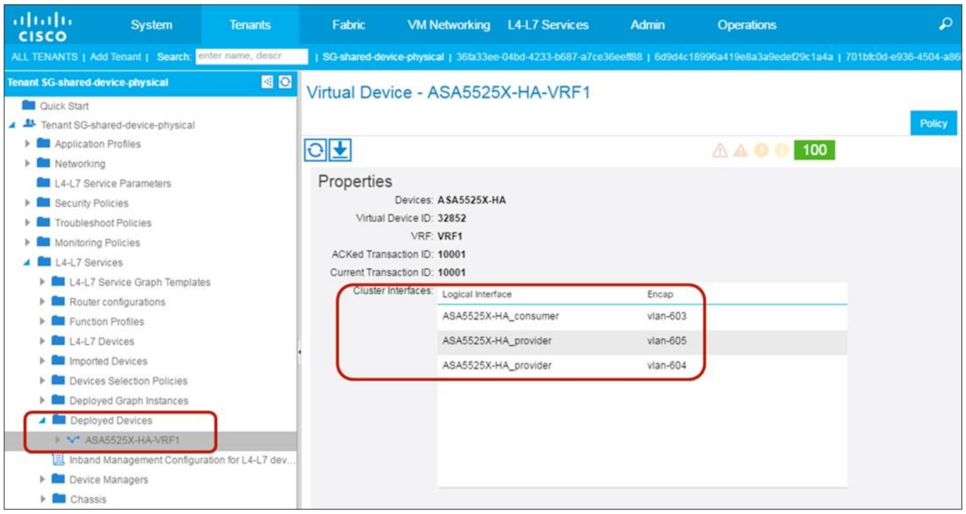
Bridge Domain: BD3

Subnets:

Virtual IP Addresses:

In this case, a total of three interfaces are created in the same service device (Figure 81).

Figure 81. Deployed Device



Virtual Device - ASA5525X-HA-VRF1

Properties

Devices: ASA5525X-HA
Virtual Device ID: 32852
VRF: VRF1
ACKed Transaction ID: 10001
Current Transaction ID: 10001
Cluster Interfaces:

Logical Interface	Encap
ASA5525X-HA_consumer	vlan-603
ASA5525X-HA_provider	vlan-605
ASA5525X-HA_provider	vlan-604

Service Graph and Function Profile Reuse

You likely have multiple service devices for various applications in multiple tenants, the service devices have some common or similar rules. You don't need to configure a different service graph for each application. This section describes how to reuse service graph templates and function profiles to use service graphs effectively.

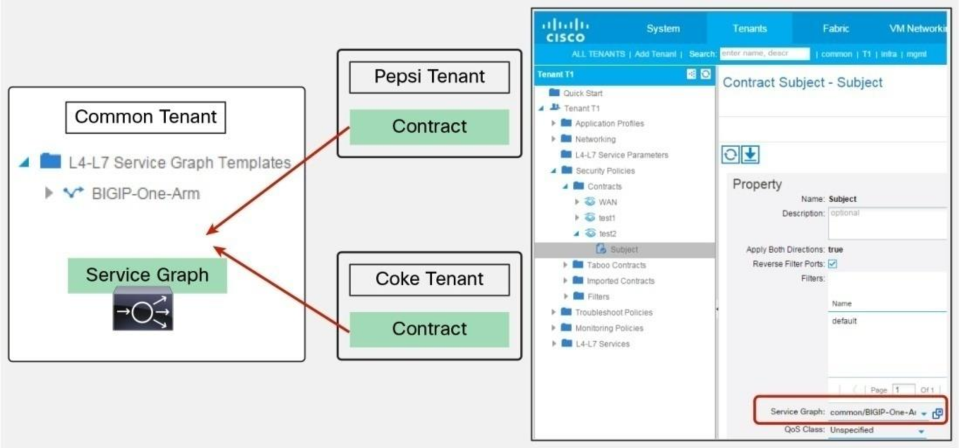
Service Graph Template Reuse

Service graph templates can be applied to multiple contracts (Figure 82). If multiple service devices have the same or similar configurations, reuse of the service graph template is an efficient and easy approach to deployment. The location where the service graph template is defined determines who can use the service graph template:

- A service graph template defined in the user tenant can be referenced only by the specific user tenant.
- A service graph template defined in the common tenant can be referenced by all user tenants.

Therefore, if you want to reuse a service graph template for contracts in multiple tenants, you need to define the service graph template in the common tenant.

Figure 82. Use Service Graph Template for Multiple Contracts



Contract Subject - Subject

Property

Name: Subject
Description: optional
Apply Both Directions: true
Reverse Filter Ports: ☑
Filters:

Name
default

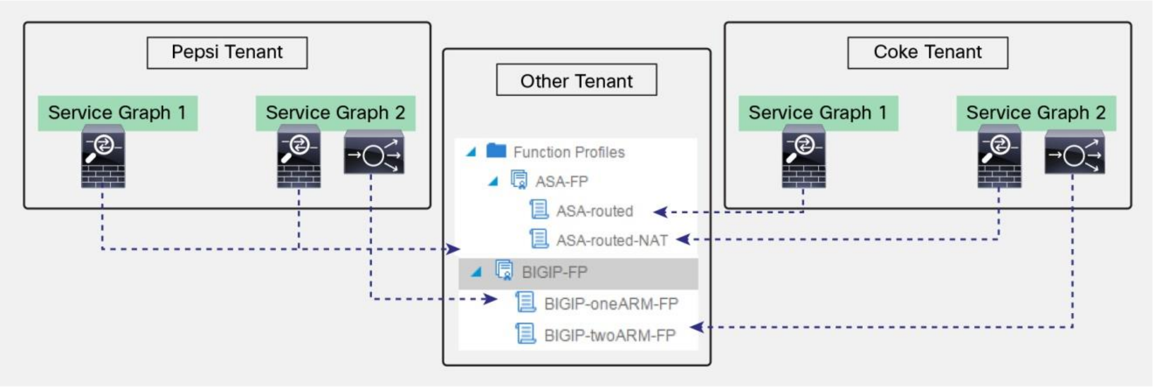
Service Graph: common/BIGIP-One-Ar
QoS Class: Unspecified

Function Profile Reuse

In creating a service graph template, you select from existing function profiles, which are collections of L4-L7 configuration parameters. Using a function profile, you can avoid having to specify L4-L7 parameters multiple times for each service graph rendering. Some function profiles with L4-L7 parameters are predefined in device packages. Users also can create function profiles meet specific design needs.

A function profile can be referenced from the user tenants in the location at which the function profile is defined. By reusing function profiles in multiple service graph templates, you can more easily deploy multiple service nodes that have the same or similar configurations (Figure 83).

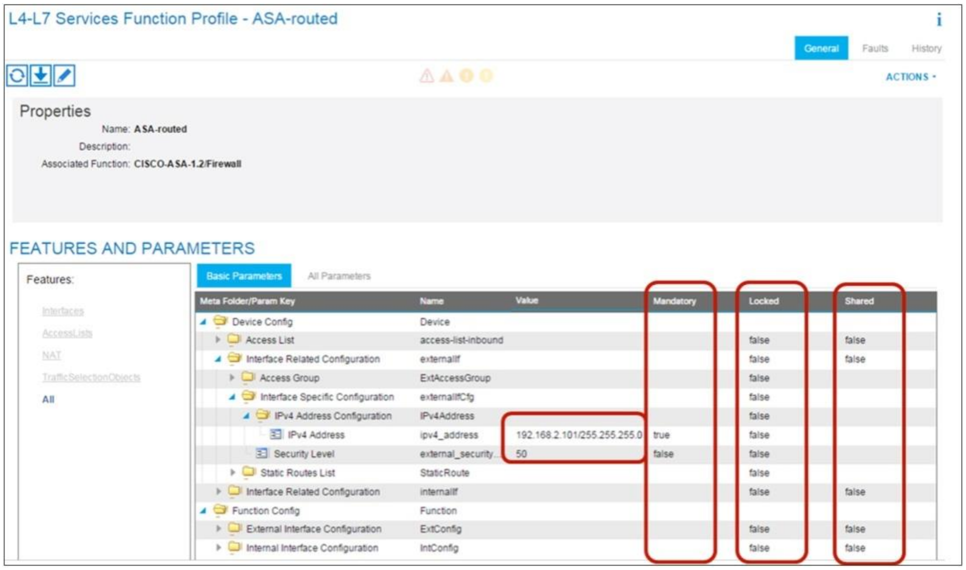
Figure 83. Use Function Profile for Multiple Service Graph Templates



Note, though, that some L4-L7 parameters differ depending on the L4-L7 deployment. Some parameters can be reused, but some cannot.

The values defined in a function profile are the default values, and you can change these for each service graph instance, which provides flexibility and enhances usability. To provide flexibility, function profiles also have options for managing parameters (Figure 84).

Figure 84. Function Profile



Name: ASA-routed
Description:
Associated Function: CISCO-ASA-1.2/Firewall

Meta Folder/Param Key	Name	Value	Mandatory	Locked	Shared
Device Config	Device				
Access List	access-list-inbound			false	false
Interface Related Configuration	externalIf			false	false
Access Group	ExtAccessGroup			false	
Interface Specific Configuration	externalIfCfg			false	
IPv4 Address Configuration	IPv4Address			false	
IPv4 Address	ipv4_address	192.168.2.101/255.255.255.0	true	false	
Security Level	external_security...	50	false	false	
Static Routes List	StaticRoute			false	
Interface Related Configuration	internalIf			false	false
Function Config	Function				
External Interface Configuration	ExtConfig			false	false
Internal Interface Configuration	IntConfig			false	false

- Mandatory: If this option is set to true, the configuration item is mandatory. For example, if the administrator wants to force the user to specify a value for a parameter, the administrator should set this option to true. If the parameter is set as mandatory in the device model that is defined in the device package, the function profile cannot override this mandatory setting.
- Locked: If this option is set to true, the parameter value set under the EPG, bridge domain, application profile, or tenant will not be used for service graph rendering. For example, if the administrator wants to use the value in the function profile at any time, the administrator should set this option to true (Figure 85).
- Shared: If this option is set to true, the parameter value in the function profile will be used if no parameter value is set under the EPG, bridge domain, application profile, or tenant. If a parameter is defined under the EPG, bridge domain, application profile, or tenant, the value in the function profile will not be used. For example, if the administrator wants to use the value in the function profile as the default, the administrator should set this option to true (Figure 86).

Figure 85. Locked Attribute: True

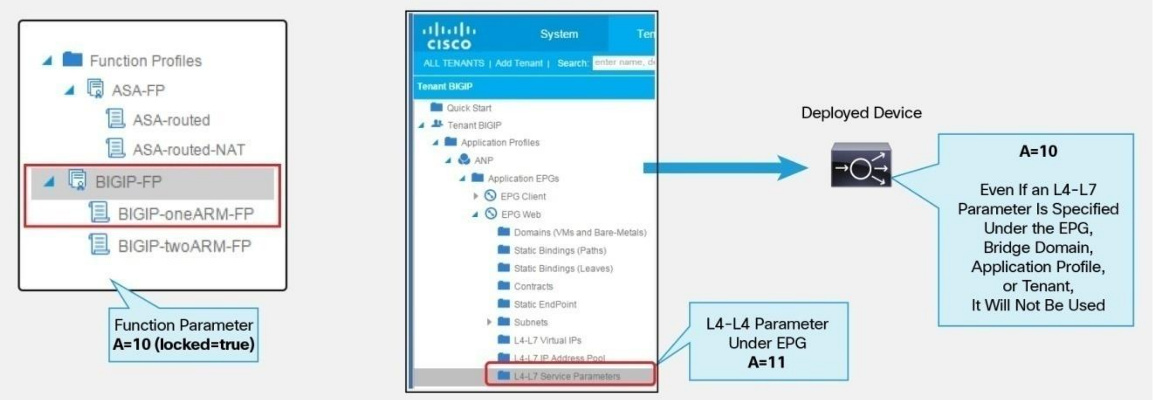
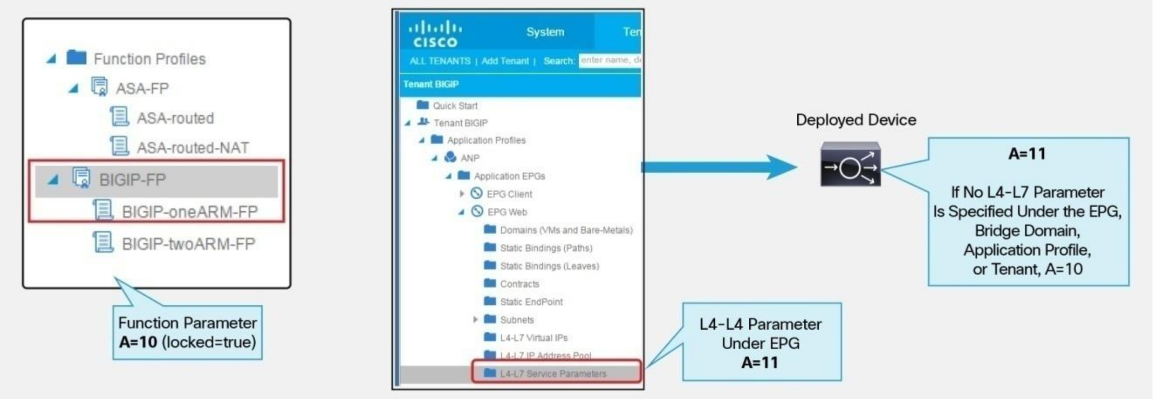


Figure 86. Shared Attribute: True



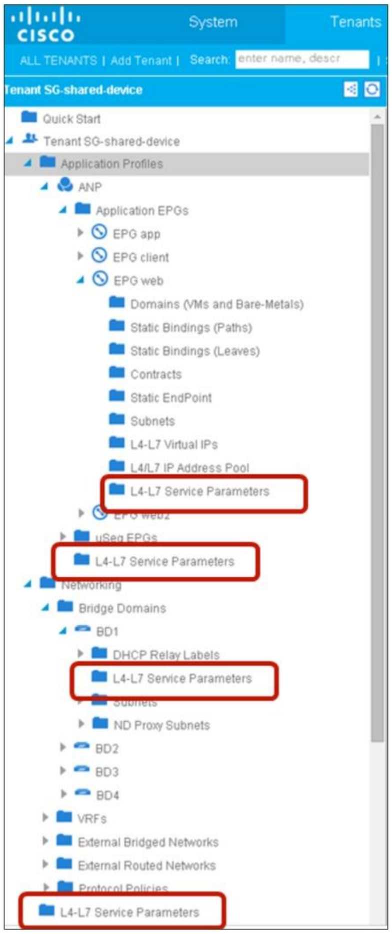
L4-L7 Parameters Best Practices

The flexibility of being able to keep L4-L7 parameters inside various managed objects allows the administrator to configure a single service graph and then reuse the graph for different tenants or EPGs with a different configuration. This section describes where you can place L4-L7 parameters.

Where L4-L7 Parameters Are Stored

L4-L7 parameters can be stored under the provider EPG, bridge domain, application profile, or tenant. When a graph is instantiated, the APIC resolves the needed configuration for a service graph by looking up the parameters in various places (Figure 87).

Figure 87. Locations of L4-L7 Parameters



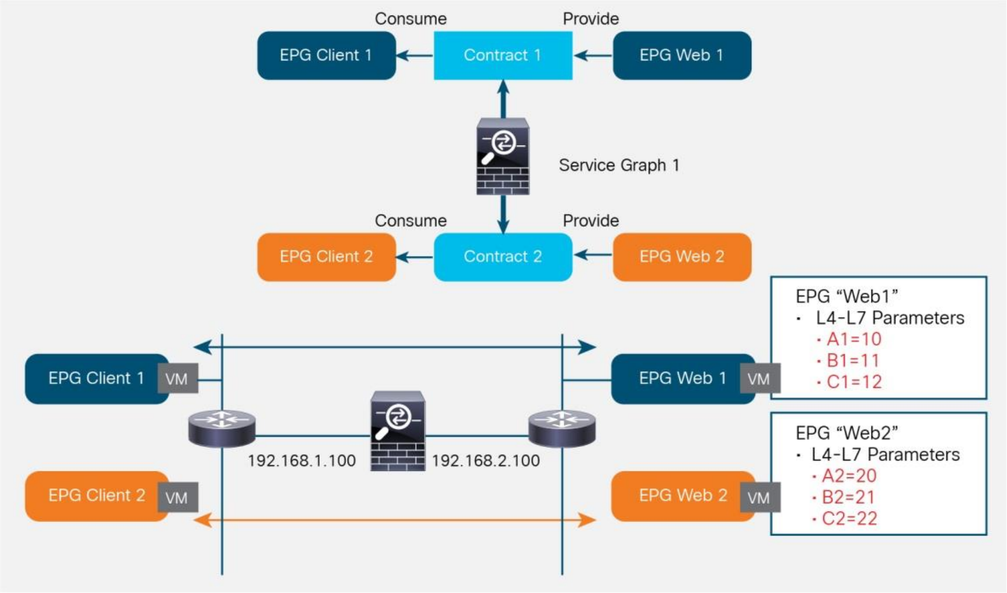
Note: This document focuses on the parameters in the function profile and under the provider EPG, application profile, and tenant for the following reasons:

- Parameters under the provider-side EPG, application profile, and tenant are used by default. The knob to change this behavior is not exposed in the GUI.
- The knob to modify the AbsNode parameter is not exposed in the GUI.

Service graph rendering looks for parameters in this order: function profile > AbsNode > EPG > application profile > tenant. By default, L4-L7 parameters are placed under the provider EPG if you use the Apply Service Graph Template wizard.

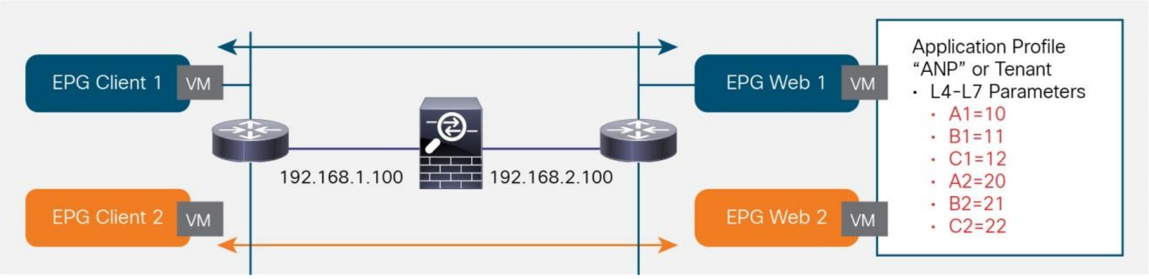
If the tenant contains multiple service graph instances with different provider EPGs, the L4-L7 parameters are stored in different places by default. You can place them in one easy-to-find place (under the application profile or tenant). For example, if you use the same ASA service graph on the same ASA appliance for multiple contracts, the L4-L7 parameters are placed under the Web1 EPG and the Web2 EPG (Figure 88), which are different APIC GUI locations.

Figure 88. Parameters Under Provider EPG



If you want, you can place the parameters under the application profile or tenant. (Figure 89).

Figure 89. Parameters Under Provider Application Profile or Tenant

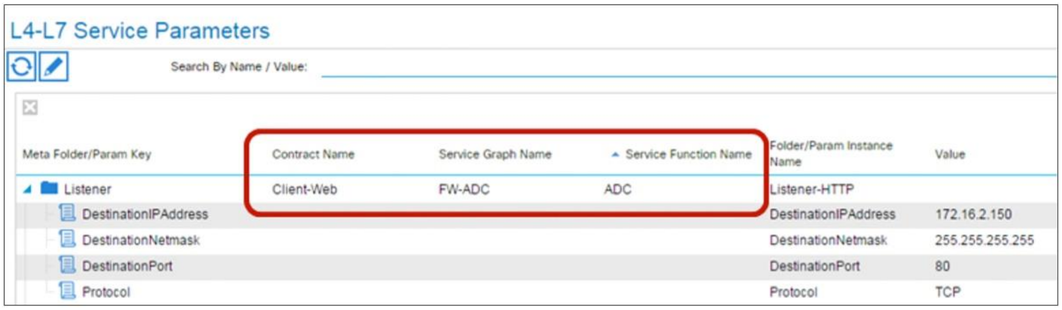


Defining Common Parameters

If you deploy multiple service graphs on the same service node with the same interface, you will want to avoid configuring the same L4-L7 parameters for the interface IP address multiple times. If you need to share L4-L7 parameters, you can explicitly define sharing by using the "any" option.

L4-L7 parameters are selected based on a combination of contract name, service graph name, and service function name. For example, the parameters in Figure 90 will be used on function ADC in the service graph FW-ADC if the service graph is deployed in the contract Client-Web.

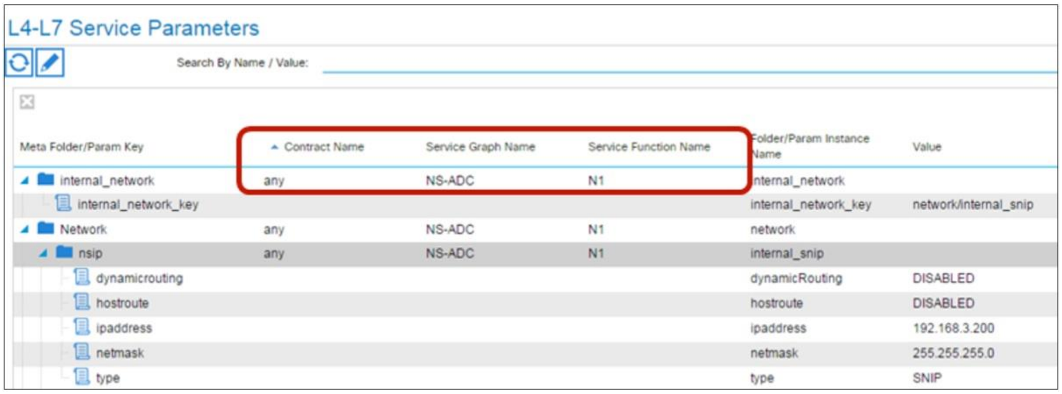
Figure 90. L4-L7 Parameter



Meta Folder/Param Key	Contract Name	Service Graph Name	Service Function Name	Folder/Param Instance Name	Value
Listener	Client-Web	FW-ADC	ADC	Listener-HTTP	
DestinationIPAddress				DestinationIPAddress	172.16.2.150
DestinationNetmask				DestinationNetmask	255.255.255.255
DestinationPort				DestinationPort	80
Protocol				Protocol	TCP

You can use the “any” option for common parameters. In the example in Figure 91, regardless of the contract name, the parameters will be used in function N1 in service graph NS-ADC. You can also use the “any” option with the service graph and service function name.

Figure 91. Using the “Any” Parameter



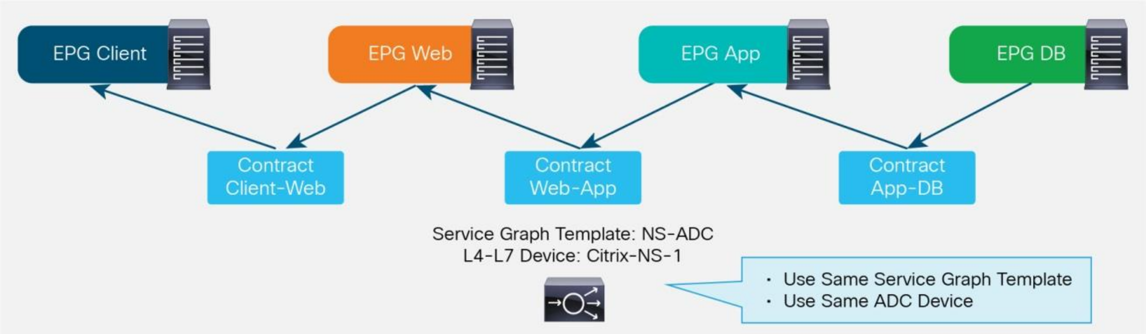
Meta Folder/Param Key	Contract Name	Service Graph Name	Service Function Name	Folder/Param Instance Name	Value
internal_network	any	NS-ADC	N1	internal_network	
internal_network_key				internal_network_key	network/internal_snip
Network	any	NS-ADC	N1	network	
nsip	any	NS-ADC	N1	internal_snip	
dynamicrouting				dynamicRouting	DISABLED
hostroute				hostroute	DISABLED
ipaddress				ipaddress	192.168.3.200
netmask				netmask	255.255.255.0
type				type	SNIP

Note: As of this writing, you can’t configure the “any” option from the GUI. You need to use the API to configure this option.

Examples

In this example, you have a three-tier application with a load balancer, and you want to use the same load balancer interface for different virtual IP addresses (Figure 92).

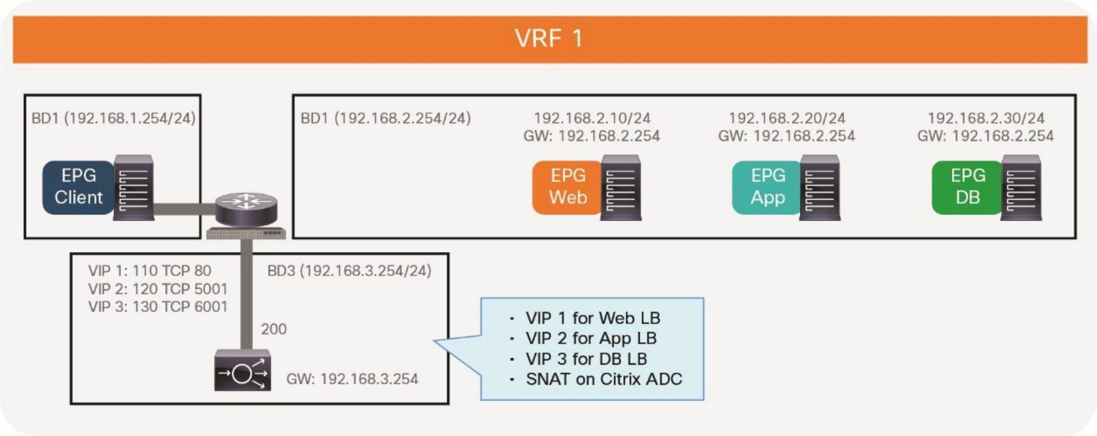
Figure 92. EPG, Contract, Service Graph Template, and L4-L7 Device Configuration



In this example (Figure 93):

- You use three contracts with the same service graph template.
- You deploy one virtual IP address for each service graph instance (three virtual IP addresses total).
- The interface configuration on the load balancer is common. The IP address is 192.168.3.200, and the default gateway is 192.168.3.254.

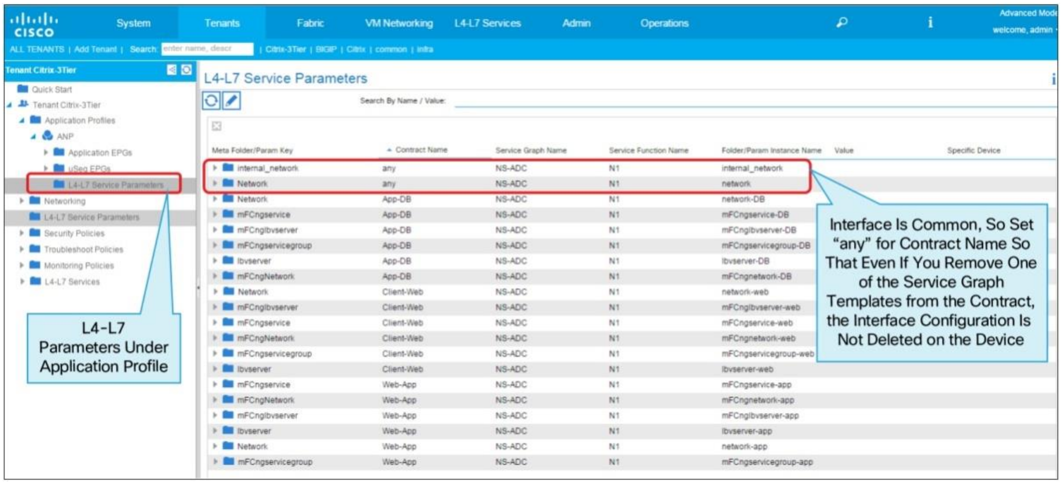
Figure 93. Bridge Domain and VRF Configuration



- VIP 1 for Web LB
- VIP 2 for App LB
- VIP 3 for DB LB
- SNAT on Citrix ADC

By configuring the “any” option for the parameters for interface IP address 192.168.3.200 and default gateway 192.168.3.254, you don’t have to enter these values multiple times. Also, even if you remove the service graph from one of contracts, the interface configuration remains. Other parameters, for example, the virtual IP address, are deployed during each service graph rendering (Figure 94).

Figure 94. L4-L7 Parameters Under Application Profile Using the “any” Option



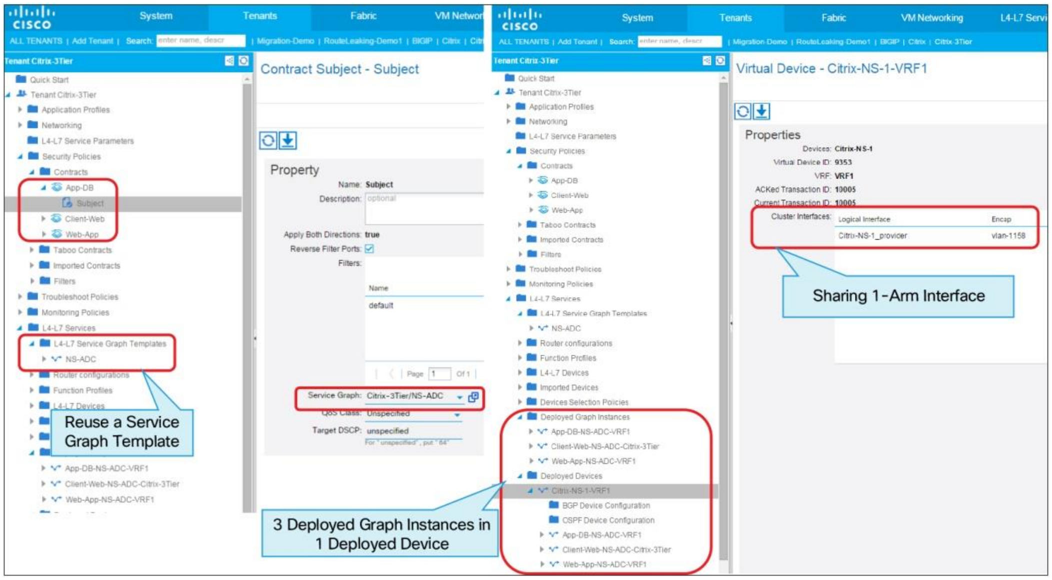
Meta Folder/Param Key	Contract Name	Service Graph Name	Service Function Name	Folder/Param Instance Name	Value	Specific Device
internal_network	any	NS-ADC	N1	internal_network		
Network	any	NS-ADC	N1	network		
Network	App-DB	NS-ADC	N1	network-DB		
mFCngservice	App-DB	NS-ADC	N1	mFCngservice-DB		
mFCnglbvserver	App-DB	NS-ADC	N1	mFCnglbvserver-DB		
mFCngservicegroup	App-DB	NS-ADC	N1	mFCngservicegroup-DB		
lbvserver	App-DB	NS-ADC	N1	lbvserver-DB		
mFCngNetwork	App-DB	NS-ADC	N1	mFCngnetwork-DB		
Network	Client-Web	NS-ADC	N1	network-web		
mFCnglbvserver	Client-Web	NS-ADC	N1	mFCnglbvserver-web		
mFCngservice	Client-Web	NS-ADC	N1	mFCngservice-web		
mFCngNetwork	Client-Web	NS-ADC	N1	mFCngnetwork-web		
mFCngservicegroup	Client-Web	NS-ADC	N1	mFCngservicegroup-web		
lbvserver	Client-Web	NS-ADC	N1	lbvserver-web		
mFCngservice	Web-App	NS-ADC	N1	mFCngservice-app		
mFCngNetwork	Web-App	NS-ADC	N1	mFCngnetwork-app		
mFCnglbvserver	Web-App	NS-ADC	N1	mFCnglbvserver-app		
lbvserver	Web-App	NS-ADC	N1	lbvserver-app		
Network	Web-App	NS-ADC	N1	network-app		
mFCngservicegroup	Web-App	NS-ADC	N1	mFCngservicegroup-app		

L4-L7 Parameters Under Application Profile

Interface Is Common, So Set “any” for Contract Name So That Even If You Remove One of the Service Graph Templates from the Contract, the Interface Configuration Is Not Deleted on the Device

Figure 95 shows an example of deployment output. In this example, the service graph template is reused for three contracts, and these all share the same interface.

Figure 95. Reusing the Same Service Graph Template and Sharing the Same Interface



Contract Subject - Subject

Property

Name: Subject

Description: optional

Apply Both Directions: true

Reverse Filter Ports: ☑

Filters:

Name
default

Page 1 Of 1

Service Graph: Citrix-3Tier/NS-ADC

QoS Class: Unspecified

Target DSCP: unspecified

For "unspecified", put "64"

Virtual Device - Citrix-NS-1-VRF1

Properties

Devices: Citrix-NS-1

Virtual Device ID: 9353

VRF: VRF1

ACKed Transaction ID: 10005

Current Transaction ID: 10005

Cluster Interfaces:

Logical Interface	Encap
Citrix-NS-1_provider	vlan-1158

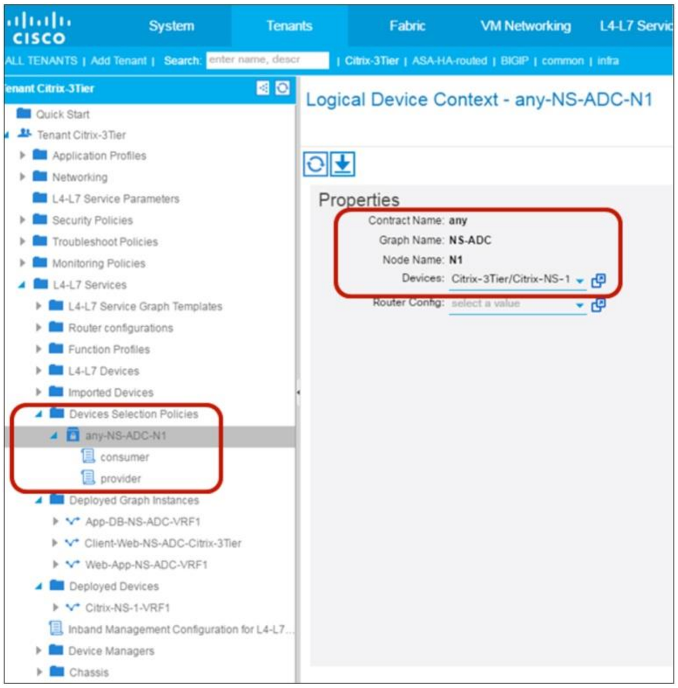
Reuse a Service Graph Template

3 Deployed Graph Instances in 1 Deployed Device

Sharing 1-Arm Interface

Device selection policy can also use the “any” option. In the example in Figure 96, by using the “any” option, you don’t have to create three device selection policies.

Figure 96. Device Selection Policy with “any” Option



Logical Device Context - any-NS-ADC-N1

Properties

Contract Name: any

Graph Name: NS-ADC

Node Name: N1

Devices: Citrix-3Tier/Citrix-NS-1

Router Config: select a value

You can also define L4-L7 device and service graph templates in the common tenant. This approach is useful when multiple tenants are using the same service device and require similar configurations.

Sample Tenant Configuration

```
<?xml version="1.0" encoding="UTF-8"?>
<imdata totalCount="1">
   <fvTenant descr="Multiple VIPs, multiple EPGs" dn="uni/tn-Citrix-3Tier"
name="Citrix-3Tier" ownerKey="" ownerTag="">
          <vnsLDevCtx ctrctNameOrLbl="any" descr="" graphNameOrLbl="NS-ADC"
name="" nodeNameOrLbl="N1">
                 <vnsRsLDevCtxToLDev tDn="uni/tn-Citrix-3Tier/lDevVip-Citrix-NS-
1"/>
                 <vnsLIfCtx connNameOrLbl="provider" descr="" name="provider">
                       <vnsRsLIfCtxToBD tDn="uni/tn-Citrix-3Tier/BD-BD3"/>
                       <vnsRsLIfCtxToLIf tDn="uni/tn-Citrix-3Tier/lDevVip-Citrix-
NS-1/lIf-provider"/>
                 </vnsLIfCtx>
                 <vnsLIfCtx connNameOrLbl="consumer" descr="" name="">
                       <vnsRsLIfCtxToBD tDn="uni/tn-Citrix-3Tier/BD-BD3"/>
                       <vnsRsLIfCtxToLIf tDn="uni/tn-Citrix-3Tier/lDevVip-Citrix-
NS-1/lIf-provider"/>
                 </vnsLIfCtx>
          </vnsLDevCtx>
          <vzBrCP descr="" name="Client-Web" ownerKey="" ownerTag=""
prio="unspecified" scope="tenant" targetDscp="unspecified">
                 <vzSubj consMatchT="AtleastOne" descr="" name="Subject"
prio="unspecified" provMatchT="AtleastOne" revFltPorts="yes"
targetDscp="unspecified">
                       <vzRsSubjFiltAtt tnVzFilterName="default"/>
                       <vzRsSubjGraphAtt tnVnsAbsGraphName="NS-ADC"/>
                 </vzSubj>
          </vzBrCP>
          <vzBrCP descr="" name="Web-App" ownerKey="" ownerTag=""
prio="unspecified" scope="context" targetDscp="unspecified">
                 <vzSubj consMatchT="AtleastOne" descr="" name="Subject"
prio="unspecified" provMatchT="AtleastOne" revFltPorts="yes"
targetDscp="unspecified">
                       <vzRsSubjFiltAtt tnVzFilterName="default"/>
                       <vzRsSubjGraphAtt tnVnsAbsGraphName="NS-ADC"/>
                 </vzSubj>
          </vzBrCP>
          <vzBrCP descr="" name="App-DB" ownerKey="" ownerTag=""
prio="unspecified" scope="context" targetDscp="unspecified">
                 <vzSubj consMatchT="AtleastOne" descr="" name="Subject"
prio="unspecified" provMatchT="AtleastOne" revFltPorts="yes"
targetDscp="unspecified">
                       <vzRsSubjFiltAtt tnVzFilterName="default"/>
                       <vzRsSubjGraphAtt tnVnsAbsGraphName="NS-ADC"/>
                 </vzSubj>
          </vzBrCP>
          <drawCont>
```

```
                <drawInst info="{'{fvNetworking/vrf}-
{VRF1}':{'x':0,'y':0,'relPos':0,'prevPos':0}}" oDn="uni/tn-Citrix-3Tier"/>
          </drawCont>
          <vnsAbsGraph descr="" name="NS-ADC" ownerKey="" ownerTag=""
uiTemplateType="UNSPECIFIED">
                <vnsAbsTermNodeCon descr="" name="T1" ownerKey="" ownerTag="">
                       <vnsAbsTermConn attNotify="no" descr="" name="1"
ownerKey="" ownerTag=""/>
                       <vnsInTerm descr="" name=""/>
                       <vnsOutTerm descr="" name=""/>
                </vnsAbsTermNodeCon>
                <vnsAbsTermNodeProv descr="" name="T2" ownerKey="" ownerTag="">
                       <vnsAbsTermConn attNotify="no" descr="" name="1"
ownerKey="" ownerTag=""/>
                       <vnsInTerm descr="" name=""/>
                       <vnsOutTerm descr="" name=""/>
                </vnsAbsTermNodeProv>
                <vnsAbsConnection adjType="L2" connDir="provider"
connType="external" descr="" name="C1" ownerKey="" ownerTag=""
unicastRoute="yes">
                       <vnsRsAbsConnectionConns tDn="uni/tn-Citrix-
3Tier/AbsGraph-NS-ADC/AbsTermNodeCon-T1/AbsTConn"/>
                       <vnsRsAbsConnectionConns tDn="uni/tn-Citrix-
3Tier/AbsGraph-NS-ADC/AbsNode-N1/AbsFConn-consumer"/>
                </vnsAbsConnection>
                <vnsAbsConnection adjType="L2" connDir="provider"
connType="external" descr="" name="C2" ownerKey="" ownerTag=""
unicastRoute="yes">
                       <vnsRsAbsConnectionConns tDn="uni/tn-Citrix-
3Tier/AbsGraph-NS-ADC/AbsTermNodeProv-T2/AbsTConn"/>
                       <vnsRsAbsConnectionConns tDn="uni/tn-Citrix-
3Tier/AbsGraph-NS-ADC/AbsNode-N1/AbsFConn-provider"/>
                </vnsAbsConnection>
                <vnsAbsNode descr="" funcTemplateType="ADC_ONE_ARM"
funcType="GoTo" managed="yes" name="N1" ownerKey="" ownerTag=""
sequenceNumber="0" shareEncap="no">
                       <vnsAbsFuncConn attNotify="no" descr="" name="consumer"
ownerKey="" ownerTag="">
                              <vnsRsMConnAtt tDn="uni/infra/mDev-Citrix-
NetScaler-1.0/mFunc-LoadBalancing/mConn-external"/>
                       </vnsAbsFuncConn>
                       <vnsAbsFuncConn attNotify="no" descr="" name="provider"
ownerKey="" ownerTag="">
                              <vnsRsMConnAtt tDn="uni/infra/mDev-Citrix-
NetScaler-1.0/mFunc-LoadBalancing/mConn-internal"/>
                       </vnsAbsFuncConn>
                       <vnsRsNodeToAbsFuncProf tDn="uni/tn-
common/absFuncProfContr/absFuncProfGrp-Citrix-FP/absFuncProf-Citrix-oneARM-FP"/>
                       <vnsRsNodeToLDev tDn="uni/tn-Citrix-3Tier/lDevVip-Citrix-
NS-1"/>
```

```
                       <vnsRsNodeToMFunc tDn="uni/infra/mDev-Citrix-NetScaler-
1.0/mFunc-LoadBalancing"/>
                <//vnsAbsNode>
          </vnsAbsGraph>
          <fvBD arpFlood="no" descr="" epMoveDetectMode=""
limitIpLearnToSubnets="no" llAddr="::" mac="00:22:BD:F8:19:FF"
multiDstPktAct="bd-flood" name="BD1" ownerKey="" ownerTag="" unicastRoute="yes"
unkMacUcastAct="proxy" unkMcastAct="flood" vmac="not-applicable">
                <fvRsBDToNdP tnNdIfPolName=""/>
                <fvRsCtx tnFvCtxName="VRF1"/>
                <fvRsIgmpsn tnIgmpSnoopPolName=""/>
                <fvSubnet ctrl="" descr="" ip="192.168.1.254/24" name=""
preferred="no" scope="private" virtual="no"/>
                <fvRsBdToEpRet resolveAct="resolve" tnFvEpRetPolName=""/>
          </fvBD>
          <fvBD arpFlood="no" descr="" epMoveDetectMode=""
limitIpLearnToSubnets="no" llAddr="::" mac="00:22:BD:F8:19:FF"
multiDstPktAct="bd-flood" name="BD3" ownerKey="" ownerTag="" unicastRoute="yes"
unkMacUcastAct="proxy" unkMcastAct="flood" vmac="not-applicable">
                <fvRsBDToNdP tnNdIfPolName=""/>
                <fvRsCtx tnFvCtxName="VRF1"/>
                <fvRsIgmpsn tnIgmpSnoopPolName=""/>
                <fvSubnet ctrl="" descr="" ip="192.168.3.254/24" name=""
preferred="no" scope="private" virtual="no"/>
                <fvRsBdToEpRet resolveAct="resolve" tnFvEpRetPolName=""/>
          </fvBD>
          <fvBD arpFlood="no" descr="" epMoveDetectMode=""
limitIpLearnToSubnets="no" llAddr="::" mac="00:22:BD:F8:19:FF"
multiDstPktAct="bd-flood" name="BD2" ownerKey="" ownerTag="" unicastRoute="yes"
unkMacUcastAct="proxy" unkMcastAct="flood" vmac="not-applicable">
                <fvRsBDToNdP tnNdIfPolName=""/>
                <fvRsCtx tnFvCtxName="VRF1"/>
                <fvRsIgmpsn tnIgmpSnoopPolName=""/>
                <fvSubnet ctrl="" descr="" ip="192.168.2.254/24" name=""
preferred="no" scope="private" virtual="no"/>
                <fvRsBdToEpRet resolveAct="resolve" tnFvEpRetPolName=""/>
          </fvBD>
          <fvCtx descr="" knwMcastAct="permit" name="VRF1" ownerKey=""
ownerTag="" pcEnfDir="ingress" pcEnfPref="enforced">
                <fvRsBgpCtxPol tnBgpCtxPolName=""/>
                <fvRsCtxToExtRouteTagPol tnL3extRouteTagPolName=""/>
                <fvRsOspfCtxPol tnOspfCtxPolName=""/>
                <vzAny descr="" matchT="AtleastOne" name=""/>
                <fvRsCtxToEpRet tnFvEpRetPolName=""/>
          </fvCtx>
          <fvAp descr="" name="ANP" ownerKey="" ownerTag="" prio="unspecified">
                <fvAEPg descr="" isAttrBasedEPg="no" matchT="AtleastOne"
name="Web" pcEnfPref="unenforced" prio="unspecified">
                       <fvRsCons prio="unspecified" tnVzBrCPName="Web-App"/>
```

```
                        <fvRsDomAtt encap="unknown" instrImedcy="lazy"
primaryEncap="unknown" resImedcy="immediate" tDn="uni/vmmp-VMware/dom-ACI_vDS"/>
                        <fvRsBd tnFvBDName="BD2"/>
                        <fvRsCustQosPol tnQosCustomPolName=""/>
                        <fvRsProv matchT="AtleastOne" prio="unspecified"
tnVzBrCPName="Client-Web"/>
                </fvAEPg>
                <fvAEPg descr="" isAttrBasedEPg="no" matchT="AtleastOne"
name="Client" pcEnfPref="unenforced" prio="unspecified">
                        <fvRsCons prio="unspecified" tnVzBrCPName="Client-Web"/>
                        <fvRsDomAtt encap="unknown" instrImedcy="lazy"
primaryEncap="unknown" resImedcy="immediate" tDn="uni/vmmp-VMware/dom-ACI_vDS"/>
                        <fvRsBd tnFvBDName="BD1"/>
                        <fvRsCustQosPol tnQosCustomPolName=""/>
                </fvAEPg>
                <fvAEPg descr="" isAttrBasedEPg="no" matchT="AtleastOne"
name="App" pcEnfPref="unenforced" prio="unspecified">
                        <fvRsCons prio="unspecified" tnVzBrCPName="App-DB"/>
                        <fvRsDomAtt encap="unknown" instrImedcy="lazy"
primaryEncap="unknown" resImedcy="immediate" tDn="uni/vmmp-VMware/dom-ACI_vDS"/>
                        <fvRsBd tnFvBDName="BD2"/>
                        <fvRsCustQosPol tnQosCustomPolName=""/>
                        <fvRsProv matchT="AtleastOne" prio="unspecified"
tnVzBrCPName="Web-App"/>
                </fvAEPg>
                <fvAEPg descr="" isAttrBasedEPg="no" matchT="AtleastOne"
name="DB" pcEnfPref="unenforced" prio="unspecified">
                        <fvRsDomAtt encap="unknown" instrImedcy="lazy"
primaryEncap="unknown" resImedcy="immediate" tDn="uni/vmmp-VMware/dom-ACI_vDS"/>
                        <fvRsBd tnFvBDName="BD2"/>
                        <fvRsCustQosPol tnQosCustomPolName=""/>
                        <fvRsProv matchT="AtleastOne" prio="unspecified"
tnVzBrCPName="App-DB"/>
                </fvAEPg>
                <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="Client-
Web" devCtxLbl="" graphNameOrLbl="NS-ADC" key="lbvserver" locked="no"
name="lbvserver-web" nodeNameOrLbl="N1" scopedBy="epg">
                        <vnsParamInst cardinality="unspecified" key="ipv46"
locked="no" mandatory="no" name="ipv46" validation="" value="192.168.3.110"/>
                        <vnsParamInst cardinality="unspecified" key="port"
locked="no" mandatory="no" name="port" validation="" value="80"/>
                        <vnsParamInst cardinality="unspecified" key="name"
locked="no" mandatory="no" name="name" validation="" value="web1"/>
                        <vnsParamInst cardinality="unspecified" key="servicetype"
locked="no" mandatory="no" name="servicetype" validation="" value="TCP"/>
                        <vnsFolderInst cardinality="unspecified"
ctrctNameOrLbl="Client-Web" devCtxLbl="" graphNameOrLbl="NS-ADC"
key="lbvserver_servicegroup_binding" locked="no"
name="lbvserver_servicegroup_binding" nodeNameOrLbl="N1" scopedBy="epg">
```

```
                              <vnsCfgRelInst cardinality="unspecified"
key="servicename" locked="no" mandatory="no" name="servicename"
targetName="servicegroup_web"/>
                       </vnsFolderInst>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="Web-
App" devCtxLbl="" graphNameOrLbl="NS-ADC" key="mFCngservice" locked="no"
name="mFCngservice-app" nodeNameOrLbl="N1" scopedBy="epg">
                       <vnsCfgRelInst cardinality="unspecified" key="service_key"
locked="no" mandatory="no" name="service_key" targetName="service-app"/>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="App-DB"
devCtxLbl="" graphNameOrLbl="NS-ADC" key="servicegroup" locked="no"
name="servicegroup_DB" nodeNameOrLbl="N1" scopedBy="epg">
                       <vnsParamInst cardinality="unspecified" key="usip"
locked="no" mandatory="no" name="usip" validation="" value="NO"/>
                       <vnsParamInst cardinality="unspecified" key="port"
locked="no" mandatory="no" name="port" validation="" value="6001"/>
                       <vnsParamInst cardinality="unspecified"
key="servicegroupname" locked="no" mandatory="no" name="servicegroupname"
validation="" value="DB"/>
                       <vnsParamInst cardinality="unspecified" key="servicetype"
locked="no" mandatory="no" name="servicetype" validation="" value="TCP"/>
                       <vnsFolderInst cardinality="unspecified"
ctrctNameOrLbl="App-DB" devCtxLbl="" graphNameOrLbl="NS-ADC"
key="servicegroup_servicegroupmember_binding" locked="no"
name="servicegroup_servicegroupmember_binding" nodeNameOrLbl="N1" scopedBy="epg">
                              <vnsParamInst cardinality="unspecified" key="ip"
locked="no" mandatory="no" name="ip" validation="" value="192.168.2.30"/>
                              <vnsParamInst cardinality="unspecified" key="port"
locked="no" mandatory="no" name="port" validation="" value="6001"/>
                       </vnsFolderInst>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="Web-
App" devCtxLbl="" graphNameOrLbl="NS-ADC" key="lbvserver" locked="no"
name="lbvserver-app" nodeNameOrLbl="N1" scopedBy="epg">
                       <vnsParamInst cardinality="unspecified" key="ipv46"
locked="no" mandatory="no" name="ipv46" validation="" value="192.168.3.120"/>
                       <vnsParamInst cardinality="unspecified" key="port"
locked="no" mandatory="no" name="port" validation="" value="5001"/>
                       <vnsParamInst cardinality="unspecified" key="name"
locked="no" mandatory="no" name="name" validation="" value="app1"/>
                       <vnsParamInst cardinality="unspecified" key="servicetype"
locked="no" mandatory="no" name="servicetype" validation="" value="TCP"/>
                       <vnsFolderInst cardinality="unspecified"
ctrctNameOrLbl="Web-App" devCtxLbl="" graphNameOrLbl="NS-ADC"
key="lbvserver_servicegroup_binding" locked="no"
name="lbvserver_servicegroup_binding" nodeNameOrLbl="N1" scopedBy="epg">
                              <vnsCfgRelInst cardinality="unspecified"
key="servicename" locked="no" mandatory="no" name="servicename"
targetName="servicegroup_app"/>
                       </vnsFolderInst>
```

```
                </vnsFolderInst>
                <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="Web-
App" devCtxLbl="" graphNameOrLbl="NS-ADC" key="mFCnglbvserver" locked="no"
name="mFCnglbvserver-app" nodeNameOrLbl="N1" scopedBy="epg">
                        <vnsCfgRelInst cardinality="unspecified"
key="lbvserver_key" locked="no" mandatory="no" name="lbvserver_key"
targetName="lbvserver-app"/>
                </vnsFolderInst>
                <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="Client-
Web" devCtxLbl="" graphNameOrLbl="NS-ADC" key="mFCngservicegroup" locked="no"
name="mFCngservicegroup-web" nodeNameOrLbl="N1" scopedBy="epg">
                        <vnsCfgRelInst cardinality="unspecified"
key="servicegroup_key" locked="no" mandatory="no" name="servicegroup_key"
targetName="servicegroup_web"/>
                </vnsFolderInst>
                <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="Client-
Web" devCtxLbl="" graphNameOrLbl="NS-ADC" key="mFCnglbvserver" locked="no"
name="mFCnglbvserver-web" nodeNameOrLbl="N1" scopedBy="epg">
                        <vnsCfgRelInst cardinality="unspecified"
key="lbvserver_key" locked="no" mandatory="no" name="lbvserver_key"
targetName="lbvserver-web"/>
                </vnsFolderInst>
                <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="App-DB"
devCtxLbl="" graphNameOrLbl="NS-ADC" key="Network" locked="no" name="network-DB"
nodeNameOrLbl="N1" scopedBy="epg">
                        <vnsFolderInst cardinality="unspecified"
ctrctNameOrLbl="App-DB" devCtxLbl="" graphNameOrLbl="NS-ADC" key="nsip"
locked="no" name="vip" nodeNameOrLbl="N1" scopedBy="epg">
                                <vnsParamInst cardinality="unspecified"
key="dynamicrouting" locked="no" mandatory="no" name="dynamicRouting"
validation="" value="DISABLED"/>
                                <vnsParamInst cardinality="unspecified"
key="ipaddress" locked="no" mandatory="no" name="ipaddress" validation=""
value="192.168.3.130"/>
                                <vnsParamInst cardinality="unspecified"
key="hostroute" locked="no" mandatory="no" name="hostroute" validation=""
value="DISABLED"/>
                                <vnsParamInst cardinality="unspecified"
key="netmask" locked="no" mandatory="no" name="netmask2" validation=""
value="255.255.255.0"/>
                                <vnsParamInst cardinality="unspecified" key="type"
locked="no" mandatory="no" name="type" validation="" value="VIP"/>
                        </vnsFolderInst>
                </vnsFolderInst>
                <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="Web-
App" devCtxLbl="" graphNameOrLbl="NS-ADC" key="service" locked="no"
name="service-app" nodeNameOrLbl="N1" scopedBy="epg">
                        <vnsParamInst cardinality="unspecified" key="ip"
locked="no" mandatory="no" name="ip" validation="" value="192.168.2.20"/>
                        <vnsParamInst cardinality="unspecified" key="port"
locked="no" mandatory="no" name="port" validation="" value="5001"/>
                        <vnsParamInst cardinality="unspecified" key="name"
locked="no" mandatory="no" name="name" validation="" value="app1"/>
```

```
                        <vnsParamInst cardinality="unspecified" key="servicetype"
locked="no" mandatory="no" name="servicetype" validation="" value="TCP"/>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="Client-
Web" devCtxLbl="" graphNameOrLbl="NS-ADC" key="mFCngservice" locked="no"
name="mFCngservice-web" nodeNameOrLbl="N1" scopedBy="epg">
                        <vnsCfgRelInst cardinality="unspecified" key="service_key"
locked="no" mandatory="no" name="service_key" targetName="service-web"/>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="Web-
App" devCtxLbl="" graphNameOrLbl="NS-ADC" key="servicegroup" locked="no"
name="servicegroup_app" nodeNameOrLbl="N1" scopedBy="epg">
                        <vnsParamInst cardinality="unspecified" key="usip"
locked="no" mandatory="no" name="usip" validation="" value="NO"/>
                        <vnsParamInst cardinality="unspecified" key="port"
locked="no" mandatory="no" name="port" validation="" value="5001"/>
                        <vnsParamInst cardinality="unspecified"
key="servicegroupname" locked="no" mandatory="no" name="servicegroupname"
validation="" value="app"/>
                        <vnsParamInst cardinality="unspecified" key="servicetype"
locked="no" mandatory="no" name="servicetype" validation="" value="TCP"/>
                        <vnsFolderInst cardinality="unspecified"
ctrctNameOrLbl="Web-App" devCtxLbl="" graphNameOrLbl="NS-ADC"
key="servicegroup_servicegroupmember_binding" locked="no"
name="servicegroup_servicegroupmember_binding" nodeNameOrLbl="N1" scopedBy="epg">
                               <vnsParamInst cardinality="unspecified" key="ip"
locked="no" mandatory="no" name="ip" validation="" value="192.168.2.20"/>
                               <vnsParamInst cardinality="unspecified" key="port"
locked="no" mandatory="no" name="port" validation="" value="5001"/>
                        </vnsFolderInst>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="Client-
Web" devCtxLbl="" graphNameOrLbl="NS-ADC" key="service" locked="no"
name="service-web" nodeNameOrLbl="N1" scopedBy="epg">
                        <vnsParamInst cardinality="unspecified" key="ip"
locked="no" mandatory="no" name="ip" validation="" value="192.168.2.10"/>
                        <vnsParamInst cardinality="unspecified" key="port"
locked="no" mandatory="no" name="port" validation="" value="80"/>
                        <vnsParamInst cardinality="unspecified" key="name"
locked="no" mandatory="no" name="name" validation="" value="web1"/>
                        <vnsParamInst cardinality="unspecified" key="servicetype"
locked="no" mandatory="no" name="servicetype" validation="" value="TCP"/>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="Web-
App" devCtxLbl="" graphNameOrLbl="NS-ADC" key="Network" locked="no"
name="network-app" nodeNameOrLbl="N1" scopedBy="epg">
                        <vnsFolderInst cardinality="unspecified"
ctrctNameOrLbl="Web-App" devCtxLbl="" graphNameOrLbl="NS-ADC" key="nsip"
locked="no" name="vip" nodeNameOrLbl="N1" scopedBy="epg">
                               <vnsParamInst cardinality="unspecified"
key="dynamicrouting" locked="no" mandatory="no" name="dynamicRouting"
validation="" value="DISABLED"/>
```

```
                              <vnsParamInst cardinality="unspecified"
key="ipaddress" locked="no" mandatory="no" name="ipaddress" validation=""
value="192.168.3.120"/>
                              <vnsParamInst cardinality="unspecified"
key="hostroute" locked="no" mandatory="no" name="hostroute" validation=""
value="DISABLED"/>
                              <vnsParamInst cardinality="unspecified"
key="netmask" locked="no" mandatory="no" name="netmask2" validation=""
value="255.255.255.0"/>
                              <vnsParamInst cardinality="unspecified" key="type"
locked="no" mandatory="no" name="type" validation="" value="VIP"/>
                       </vnsFolderInst>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="Client-
Web" devCtxLbl="" graphNameOrLbl="NS-ADC" key="mFCngNetwork" locked="no"
name="mFCngnetwork-web" nodeNameOrLbl="N1" scopedBy="epg">
                       <vnsCfgRelInst cardinality="unspecified" key="Network_key"
locked="no" mandatory="no" name="Network_key" targetName="network-web/vip"/>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="App-DB"
devCtxLbl="" graphNameOrLbl="NS-ADC" key="mFCngNetwork" locked="no"
name="mFCngnetwork-DB" nodeNameOrLbl="N1" scopedBy="epg">
                       <vnsCfgRelInst cardinality="unspecified" key="Network_key"
locked="no" mandatory="no" name="Network_key" targetName="network-DB/vip"/>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="Client-
Web" devCtxLbl="" graphNameOrLbl="NS-ADC" key="Network" locked="no"
name="network-web" nodeNameOrLbl="N1" scopedBy="epg">
                       <vnsFolderInst cardinality="unspecified"
ctrctNameOrLbl="Client-Web" devCtxLbl="" graphNameOrLbl="NS-ADC" key="nsip"
locked="no" name="vip" nodeNameOrLbl="N1" scopedBy="epg">
                              <vnsParamInst cardinality="unspecified"
key="dynamicrouting" locked="no" mandatory="no" name="dynamicRouting"
validation="" value="DISABLED"/>
                              <vnsParamInst cardinality="unspecified"
key="ipaddress" locked="no" mandatory="no" name="ipaddress" validation=""
value="192.168.3.110"/>
                              <vnsParamInst cardinality="unspecified"
key="hostroute" locked="no" mandatory="no" name="hostroute" validation=""
value="DISABLED"/>
                              <vnsParamInst cardinality="unspecified"
key="netmask" locked="no" mandatory="no" name="netmask2" validation=""
value="255.255.255.0"/>
                              <vnsParamInst cardinality="unspecified" key="type"
locked="no" mandatory="no" name="type" validation="" value="VIP"/>
                       </vnsFolderInst>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="any"
devCtxLbl="" graphNameOrLbl="NS-ADC" key="Network" locked="no" name="network"
nodeNameOrLbl="N1" scopedBy="epg">
                       <vnsFolderInst cardinality="unspecified"
ctrctNameOrLbl="any" devCtxLbl="" graphNameOrLbl="NS-ADC" key="route" locked="no"
name="route" nodeNameOrLbl="N1" scopedBy="epg">
```

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                              <vnsParamInst cardinality="unspecified"
key="netmask" locked="no" mandatory="no" name="netmask" validation=""
value="255.255.0.0"/>
                              <vnsParamInst cardinality="unspecified"
key="network" locked="no" mandatory="no" name="network" validation=""
value="192.168.0.0"/>
                              <vnsParamInst cardinality="unspecified"
key="gateway" locked="no" mandatory="no" name="gateway" validation=""
value="192.168.3.254"/>
                       </vnsFolderInst>
                       <vnsFolderInst cardinality="unspecified"
ctrctNameOrLbl="any" devCtxLbl="" graphNameOrLbl="NS-ADC" key="nsip" locked="no"
name="internal_snip" nodeNameOrLbl="N1" scopedBy="epg">
                              <vnsParamInst cardinality="unspecified"
key="dynamicrouting" locked="no" mandatory="no" name="dynamicRouting"
validation="" value="DISABLED"/>
                              <vnsParamInst cardinality="unspecified"
key="ipaddress" locked="no" mandatory="no" name="ipaddress" validation=""
value="192.168.3.200"/>
                              <vnsParamInst cardinality="unspecified"
key="hostroute" locked="no" mandatory="no" name="hostroute" validation=""
value="DISABLED"/>
                              <vnsParamInst cardinality="unspecified"
key="netmask" locked="no" mandatory="no" name="netmask" validation=""
value="255.255.255.0"/>
                              <vnsParamInst cardinality="unspecified" key="type"
locked="no" mandatory="no" name="type" validation="" value="SNIP"/>
                       </vnsFolderInst>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="any"
devCtxLbl="" graphNameOrLbl="NS-ADC" key="internal_network" locked="no"
name="internal_network" nodeNameOrLbl="N1" scopedBy="epg">
                       <vnsCfgRelInst cardinality="unspecified"
key="internal_network_key" locked="no" mandatory="no" name="internal_network_key"
targetName="network/internal_snip"/>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="App-DB"
devCtxLbl="" graphNameOrLbl="NS-ADC" key="lbvserver" locked="no" name="lbvserver-
DB" nodeNameOrLbl="N1" scopedBy="epg">
                       <vnsParamInst cardinality="unspecified" key="ipv46"
locked="no" mandatory="no" name="ipv46" validation="" value="192.168.3.130"/>
                       <vnsParamInst cardinality="unspecified" key="port"
locked="no" mandatory="no" name="port" validation="" value="6001"/>
                       <vnsParamInst cardinality="unspecified" key="name"
locked="no" mandatory="no" name="name" validation="" value="DB1"/>
                       <vnsParamInst cardinality="unspecified" key="servicetype"
locked="no" mandatory="no" name="servicetype" validation="" value="TCP"/>
                       <vnsFolderInst cardinality="unspecified"
ctrctNameOrLbl="App-DB" devCtxLbl="" graphNameOrLbl="NS-ADC"
key="lbvserver_servicegroup_binding" locked="no"
name="lbvserver_servicegroup_binding" nodeNameOrLbl="N1" scopedBy="epg">
                              <vnsCfgRelInst cardinality="unspecified"
key="servicename" locked="no" mandatory="no" name="servicename"
targetName="servicegroup_DB"/>
```

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                        </vnsFolderInst>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="App-DB"
devCtxLbl="" graphNameOrLbl="NS-ADC" key="mFCngservicegroup" locked="no"
name="mFCngservicegroup-DB" nodeNameOrLbl="N1" scopedBy="epg">
                        <vnsCfgRelInst cardinality="unspecified"
key="servicegroup_key" locked="no" mandatory="no" name="servicegroup_key"
targetName="servicegroup_DB"/>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="App-DB"
devCtxLbl="" graphNameOrLbl="NS-ADC" key="service" locked="no" name="service-DB"
nodeNameOrLbl="N1" scopedBy="epg">
                        <vnsParamInst cardinality="unspecified" key="ip"
locked="no" mandatory="no" name="ip" validation="" value="192.168.2.30"/>
                        <vnsParamInst cardinality="unspecified" key="port"
locked="no" mandatory="no" name="port" validation="" value="6001"/>
                        <vnsParamInst cardinality="unspecified" key="name"
locked="no" mandatory="no" name="name" validation="" value="DB1"/>
                        <vnsParamInst cardinality="unspecified" key="servicetype"
locked="no" mandatory="no" name="servicetype" validation="" value="TCP"/>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="Client-
Web" devCtxLbl="" graphNameOrLbl="NS-ADC" key="servicegroup" locked="no"
name="servicegroup_web" nodeNameOrLbl="N1" scopedBy="epg">
                        <vnsParamInst cardinality="unspecified" key="usip"
locked="no" mandatory="no" name="usip" validation="" value="NO"/>
                        <vnsParamInst cardinality="unspecified" key="port"
locked="no" mandatory="no" name="port" validation="" value="80"/>
                        <vnsParamInst cardinality="unspecified"
key="servicegroupname" locked="no" mandatory="no" name="servicegroupname"
validation="" value="web"/>
                        <vnsParamInst cardinality="unspecified" key="servicetype"
locked="no" mandatory="no" name="servicetype" validation="" value="TCP"/>
                        <vnsFolderInst cardinality="unspecified"
ctrctNameOrLbl="Client-Web" devCtxLbl="" graphNameOrLbl="NS-ADC"
key="servicegroup_servicegroupmember_binding" locked="no"
name="servicegroup_servicegroupmember_binding" nodeNameOrLbl="N1" scopedBy="epg">
                               <vnsParamInst cardinality="unspecified" key="ip"
locked="no" mandatory="no" name="ip" validation="" value="192.168.2.10"/>
                               <vnsParamInst cardinality="unspecified" key="port"
locked="no" mandatory="no" name="port" validation="" value="80"/>
                        </vnsFolderInst>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="App-DB"
devCtxLbl="" graphNameOrLbl="NS-ADC" key="mFCnglbvserver" locked="no"
name="mFCnglbvserver-DB" nodeNameOrLbl="N1" scopedBy="epg">
                        <vnsCfgRelInst cardinality="unspecified"
key="lbvserver_key" locked="no" mandatory="no" name="lbvserver_key"
targetName="lbvserver-DB"/>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="App-DB"
devCtxLbl="" graphNameOrLbl="NS-ADC" key="mFCngservice" locked="no"
name="mFCngservice-DB" nodeNameOrLbl="N1" scopedBy="epg">
                       <vnsCfgRelInst cardinality="unspecified" key="service_key"
locked="no" mandatory="no" name="service_key" targetName="service-DB"/>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="Web-
App" devCtxLbl="" graphNameOrLbl="NS-ADC" key="mFCngNetwork" locked="no"
name="mFCngnetwork-app" nodeNameOrLbl="N1" scopedBy="epg">
                       <vnsCfgRelInst cardinality="unspecified" key="Network_key"
locked="no" mandatory="no" name="Network_key" targetName="network-app/vip"/>
                 </vnsFolderInst>
                 <vnsFolderInst cardinality="unspecified" ctrctNameOrLbl="Web-
App" devCtxLbl="" graphNameOrLbl="NS-ADC" key="mFCngservicegroup" locked="no"
name="mFCngservicegroup-app" nodeNameOrLbl="N1" scopedBy="epg">
                       <vnsCfgRelInst cardinality="unspecified"
key="servicegroup_key" locked="no" mandatory="no" name="servicegroup_key"
targetName="servicegroup_app"/>
                 </vnsFolderInst>
          </fvAp>
          <fvRsTenantMonPol tnMonEPGPolName=""/>
          <vnsLDevVip contextAware="single-Context" devtype="VIRTUAL"
funcType="GoTo" managed="yes" mode="legacy-Mode" name="Citrix-NS-1"
svcType="ADC">
                 <vnsCCred name="username" value="nsroot"/>
                 <vnsRsMDevAtt tDn="uni/infra/mDev-Citrix-NetScaler-1.0"/>
                 <vnsCCredSecret name="password"/>
                 <vnsCMgmt host="172.31.185.3" name="" port="80"/>
                 <vnsRsALDevToDomP tDn="uni/vmmp-VMware/dom-ACI_vDS"/>
                 <vnsCDev devCtxLbl="" name="Citrix-NS-1_Device_1"
vcenterName="vCenter-5.5" vmName="Citrix-NS-1">
                       <vnsCCred name="username" value="nsroot"/>
                       <vnsCCredSecret name="password"/>
                       <vnsCMgmt host="172.31.185.3" name="" port="80"/>
                       <vnsCIf name="1_1" vnicName="Network adapter 2"/>
                       <vnsCIf name="1_2" vnicName="Network adapter 3"/>
                       <vnsRsCDevToCtrlrP tDn="uni/vmmp-VMware/dom-ACI_vDS/ctrlr-
vCenter-5.5"/>
                 </vnsCDev>
                 <vnsLIf encap="unknown" name="provider">
                       <vnsRsMetaIf isConAndProv="no" tDn="uni/infra/mDev-Citrix-
NetScaler-1.0/mIfLbl-inside"/>
                       <vnsRsCIfAttN tDn="uni/tn-Citrix-3Tier/lDevVip-Citrix-NS-
1/cDev-Citrix-NS-1_Device_1/cIf-[1_2]"/>
                 </vnsLIf>
                 <vnsLIf encap="unknown" name="consumer">
                       <vnsRsMetaIf isConAndProv="no" tDn="uni/infra/mDev-Citrix-
NetScaler-1.0/mIfLbl-outside"/>
                       <vnsRsCIfAttN tDn="uni/tn-Citrix-3Tier/lDevVip-Citrix-NS-
1/cDev-Citrix-NS-1_Device_1/cIf-[1_1]"/>
```

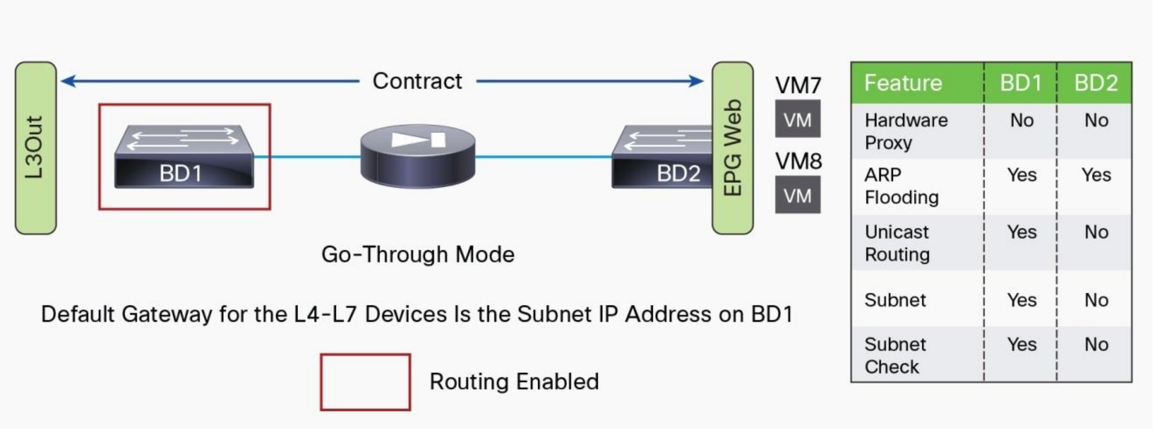
```
                 </vnsLIf>
          </vnsLDevVip>
   </fvTenant>
</imdata>
```

Example

This section provides an example that shows how to deploy a service graph with a Cisco ASA firewall. The previous sections presented the steps for configuring an L4-L7 service graph common to all L4-L7 services and that also applies to the ASA firewall. This section completes the previous section with information specific to ASA.

Figure 97 illustrates the deployment example.

Figure 97. Cisco ASA Deployed in Transparent Mode


L3Out
Contract
BD1
BD2
EPG Web
VM7
VM
VM8
VM
Go-Through Mode
Default Gateway for the L4-L7 Devices Is the Subnet IP Address on BD1
Routing Enabled

Feature	BD1	BD2
Hardware Proxy	No	No
ARP Flooding	Yes	Yes
Unicast Routing	Yes	No
Subnet	Yes	No
Subnet Check	Yes	No

Management Configuration on Cisco ASA and ASAv

Perform the following steps on the ASA or ASAv:

1. Verify that HTTP and HTTPS management is defined.
2. Verify that Secure Shell (SSH) access is configured.
3. Verify that you can log in to the ASA through SSH.

The ASA doesn’t use the concept of a management VRF instance, so you should use the routing table on the ASA for traffic forwarding, not for management traffic. Therefore, you should have a management station on the same subnet as the management port of the ASA, or you should use the instructions for in-band management.

Fabric and Access Policy Configuration

Perform the following steps in Cisco ACI:

- If you are using a physical ASA device, define the physical domain for the ASA ports with a dynamic VLAN pool.
- If you are using ASAv, define the virtual domain with a dynamic VLAN pool.

As with the other Cisco ACI configurations, you should define the Attachable Entity Profile (AEP), the policy group, and so on.

If you are using a physical ASA, you likely will want to use a vPC to connect it to Cisco ACI. In this case, you need to create a policy group type of vPC.

Make sure that the Link Aggregation Control Protocol (LACP) policy defines the maximum LACP value as 8 (at the time of this writing, an error in the device package on the ASA side requires the maximum LACP value to be set to 8).

Data Path Configuration for Transparent Mode

As previously explained, you need to configure the data path for transparent mode as follows:

- Create two bridge domains.
- Configure unknown unicast flooding, ARP flooding, and unicast routing as necessary.

The following list shows the configurations for an ASA deployed in transparent mode:

- Bridge domain outside or client facing (consumer side)
  - Enable unicast routing.
  - Enable unknown unicast flooding.
  - Enable ARP flooding.
  - The subnet definition on the bridge domain is the default gateway for the servers.
- Bridge domain internal or server facing (provider side):
  - Disable unicast routing.
  - Enable unknown unicast flooding.
  - Enable ARP flooding.
  - The subnet definition on the bridge domain is irrelevant.

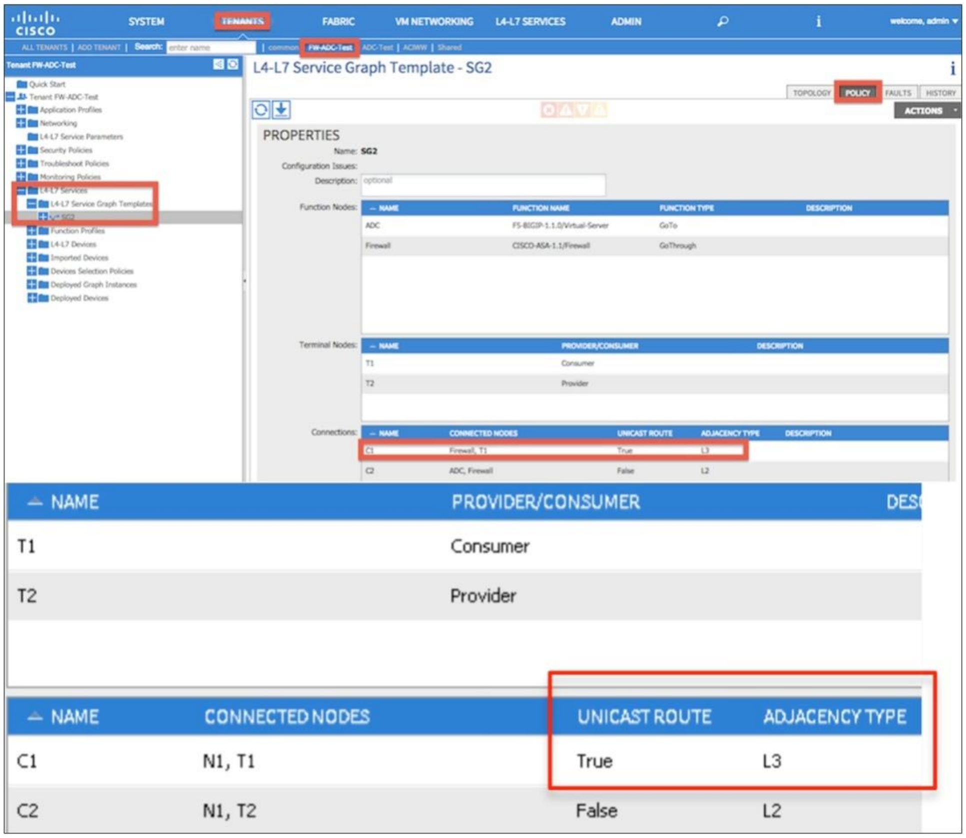
You need to associate both bridge domains with a VRF instance to make the Cisco ACI object model consistent.

You then create EPGs for the client and server sides, create a template, apply the template, and provide the L4-L7 parameters.

The next section explains which parameters to configure.

After you apply the service graph template, if you expect the outside bridge domain to perform the default gateway function for the firewall, you need to change the adjacency type for the connector of the external interface of the ASA to Layer 3. You also need to enable unicast routing. You need to take these steps to bring up the Switch Virtual Interface (SVI) on the bridge domain (Figure 98).

Figure 98. Configuration of the Layer 3 Connector



L4-L7 Service Graph Template - SG2

PROPERTIES

Name: SG2

Configuration Issues:

Description: optional

Function Nodes:

NAME	FUNCTION NAME	FUNCTION TYPE	DESCRIPTION
ADC	F5-BIGIP-1.1.0/Virtual-Server	GoTo	
Firewall	CISCO-ASA-1.1/Firewall	GoThrough	

Terminal Nodes:

NAME	PROVIDER/CONSUMER	DESCRIPTION
T1	Consumer	
T2	Provider	

Connections:

NAME	CONNECTED NODES	UNICAST ROUTE	ADJACENCY TYPE	DESCRIPTION
C1	Firewall, T1	True	L3	
C2	ADC, Firewall	False	L2	

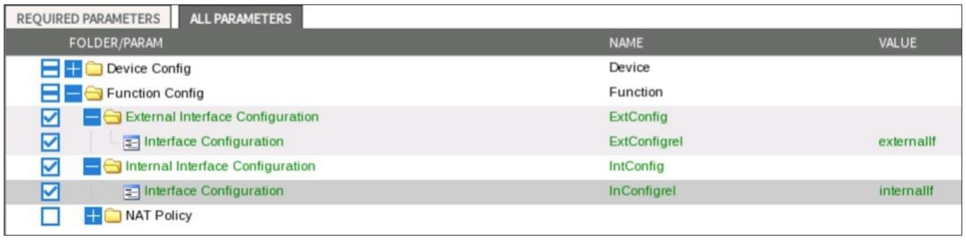
NAME	PROVIDER/CONSUMER	DES
T1	Consumer	
T2	Provider	

NAME	CONNECTED NODES	UNICAST ROUTE	ADJACENCY TYPE
C1	N1, T1	True	L3
C2	N1, T2	False	L2

L4-L7 Parameters for Transparent Mode

Even if all the required parameters are listed on the Required Parameters tab, you should select the All Parameters tab (Figure 99). Here you should configure **externalIf** and **internalIf**.

Figure 99. Entering L4-L7 Parameters for Cisco ASA



	FOLDER/PARAM	NAME	VALUE
	Device Config	Device	
	Function Config	Function	
☑	External Interface Configuration	ExtConfig	
☑	Interface Configuration	ExtConfigrel	externalIf
☑	Internal Interface Configuration	IntConfig	
☑	Interface Configuration	InConfigrel	internalIf
□	NAT Policy		

You then need to create a bridge group to implement transparent mode, and you need to define an IP address for the bridge group. You can perform this configuration from the All Parameters tab. The IP address and mask that you configure in the parameters must follow the format used in this example: 10.10.10.5/255.255.255.128. The format is “/” without spaces, followed by the mask and not just a mask length (for example, not just /25).

XML Configuration for Cisco ASAv Deployed in Transparent Mode

This section shows the XML configuration for the ASAv deployed in transparent mode.

Creating the Tenant

```
<polUni>
<fvTenant name="Sales">

  <!-- Creates VRF -->
  <fvCtx name="Salesctx1"/>

  <!-- bridge domain -->
  <fvBD name="SalesBDOutside" arpFlood="yes" unicastRoute="yes"
unkMacUcastAct="flood" unkMcastAct="flood">
    <fvRsCtx tnFvCtxName="Salesctx1" />
    <fvSubnet ip="30.0.0.2/24" />
  </fvBD>

  <!-- bridge domain -->
  <fvBD name="SalesBDInside" arpFlood="yes" unicastRoute="no"
unkMacUcastAct="flood" unkMcastAct="flood">
    <fvRsCtx tnFvCtxName="Salesctx1" />
  </fvBD>

  <fvAp  name="orderingtool">
   <fvAEPg  matchT="AtleastOne" name="app" >
     <fvRsDomAtt instrImedcy="lazy" resImedcy="immediate" tDn="uni/vmmp-
VMware/dom-vCenterACI2">
     </fvRsDomAtt>
     <fvRsBd tnFvBDName="SalesBDInside"/>
   </fvAEPg>
    </fvAp>
</fvTenant>
</polUni>
```

Creating the Contract

```
<polUni>
 <fvTenant dn="uni/tn-Sales" name="Sales">
    <!-- setting scope to Tenant so that the contract can also be used across 
VRFs if needed -->
    <vzBrCP  name="webtoapp" scope="tenant">
   <vzSubj name="alltraffic" provMatchT="AtleastOne" revFltPorts="yes">
   <vzRsSubjFiltAtt tnVzFilterName="default"/>
   </vzSubj>
    </vzBrCP>


    <fvAp name="orderingtool">
   <fvAEPg matchT="AtleastOne" name="app">
         <fvRsProv tnVzBrCPName="webtoapp"/>
   </fvAEPg>
    </fvAp>


 <l3extOut  name="Internet">
     <!-- Definition of the external EPG -->
     <!-- The External EPG Consumes the Contract provided by EPG app -->
        <l3extInstP  matchT="AtleastOne" name="InternetEPG">
          <fvRsCons tnVzBrCPName="webtoapp"/>
       </l3extInstP>
     </l3extOut>
 </fvTenant>
</polUni>
```

Creating CDev and LDev

```
<polUni>
<fvTenant name="Sales">


<!-- Definition of the logical device, i.e. the cluster of ASA -->
<vnsLDevVip contextAware="single-Context" devtype="VIRTUAL" name="ASAv01-cluster" 
funcType="GoThrough" managed="yes" mode="legacy-Mode" svcType="FW">
   <vnsCCred name="username" value="admin"/>
     <!-- This specifies which device package to use, in this case CISCO-ASA-1.2 
-->
     <vnsRsMDevAtt tDn="uni/infra/mDev-CISCO-ASA-1.2"/>
   <!-- This specifies which vCenter to use, i.e. the one defined as vCenterACI2 
-->
   <vnsRsALDevToDomP tDn="uni/vmmp-VMware/dom-vCenterACI2"/>


  <!-- This tells ACI how to manage the ASA device and on which port -->
  <!-- This configuration refers to the "cluster" of ASA -->
  <!-- So if there is a single device this configuration is repeated for the only 
device (see below) -->
```

```
   <vnsCMgmt name="devMgmt"  host="172.28.80.120" port="443"/>
   <vnsCCredSecret name="password" value="tme12345"/>

  <!-- ASA-1 is the name that you give to the configuration for one device -->
  <!-- It is referenced by lDevVip-ASAv01-cluster/cDev-ASA-1/cIf-*** -->
  <!-- If this configuration had two devices in the cluster you would have
another similar configuration -->
  <!-- vCenterACI2 is the name of the vCenter host -->
  <!-- the vmNAME is the name of the ASA virtual appliance -->
   <vnsCDev devCtxLbl="" name="ASA-1" vcenterName="vcenter-brazos" vmName="ASAv">

    <!-- Network Adapter 1 is used for Management -->
        <!-- so the list here starts from Network Adapter 2 -->

        <!-- GigabitEthernet0/0 is not an arbitrary name, it indicates the
inteface from ASA -->
        <!-- This is telling ACI that interface Network Adapter 2 is mapped to
Gig0/0 in ASA -->
        <vnsCIf name="GigabitEthernet0/0" vnicName="Network adapter 2"/>
        <!-- GigabitEthernet0/1 is not an arbitrary name, it indicates the
inteface from ASA -->
        <!-- This is telling ACI that interface Network Adapter 3 is mapped to
Gig0/1 in ASA -->
    <vnsCIf name="GigabitEthernet0/1" vnicName="Network adapter 3"/>

    <!-- Because there's a single device in this cluster this configuration is
identical to the previous one -->
    <vnsCMgmt name="devMgmt" host="172.28.80.120" port="443"/>
    <vnsCCred name="username" value="admin"/>
    <vnsCCredSecret name="password" value="tme12345"/>
   </vnsCDev>
   <!-- The logical interface is the abstraction of the interface that represents
the cluster -->
       <!-- in the case of a cluster with a single device, the logical interface
includes -->
       <!-- the interface of the "concrete" device -->

       <vnsLIf name="ASAClusterExt">
      <vnsRsMetaIf tDn="uni/infra/mDev-CISCO-ASA-1.2/mIfLbl-external"/>
      <!-- lDevVip-ASAv01-cluster uses the name of the LDev that you previously
defined -->
      <vnsRsCIfAtt tDn="uni/tn-Sales/lDevVip-ASAv01-cluster/cDev-ASA-1/cIf-
[GigabitEthernet0/0]"/>
     </vnsLIf>
     <vnsLIf name="ASAClusterInt">
       <vnsRsMetaIf tDn="uni/infra/mDev-CISCO-ASA-1.2/mIfLbl-internal"/>
       <!-- lDevVip-ASAv01-cluster uses the name of the LDev that you previously
defined -->
```

```
          <vnsRsCIfAtt tDn="uni/tn-Sales/lDevVip-ASAv01-cluster/cDev-ASA-1/cIf-
[GigabitEthernet0/1]"/>
      </vnsLIf>
</vnsLDevVip>
</fvTenant>
</polUni>
```

Creating the Service Graph Template

```
<polUni>
 <fvTenant name="Sales">

<!-- This is the name of the graph -->
<!-- it is referenced when you associate with the contract -->

  <vnsAbsGraph name="FW-bridged">

  <!-- This is the Outside "connector" of the graph -->
  <!-- The name is referenced by AbsTermNodeProv-ServerSide/AbsTConn -->
    <vnsAbsTermNodeCon name="OutsideTerminalConnector">
     <vnsAbsTermConn attNotify="no" name="1"/>
     <vnsInTerm name="input-terminal"/>
     <vnsOutTerm name="output-terminal"/>
    </vnsAbsTermNodeCon>

    <!-- This is the Inside "connector" of the graph -->
    <!-- The name is referenced by AbsTermNodeCon-ClientSide/AbsTConn -->
    <vnsAbsTermNodeProv name="InsideTerminalConnector">
   <vnsAbsTermConn attNotify="no" name="1" />
   <vnsInTerm name="input-terminal"/>
   <vnsOutTerm name="output-terminal"/>
    </vnsAbsTermNodeProv>

    <!-- This defines the name of the node in the graph -->
    <!-- The name is referenced by "AbsNode-ASA-1-node/AbsFConn-****" -->
    <vnsAbsNode funcTemplateType="FW_TRANS" funcType="GoThrough" name="ASA-1-
node">
   <!-- This specifies which function this is -->
   <vnsRsNodeToMFunc tDn="uni/infra/mDev-CISCO-ASA-1.2/mFunc-Firewall"/>

    <!-- This is the name of the connectivity point of the node -->
    <!-- the name is referenced by AbsNode-ASA-1-node/AbsFConn-ASAnodeoutside -->

    <vnsAbsFuncConn attNotify="no" name="ASAnodeoutside">
    <!-- This is the Metadevice information i.e. the mConnector -->
    <!-- "external" is not an arbitrary name, it is the definition of the type of
interface -->
```

```
    <!-- and it has a precise meaning in the meta device -->
     <vnsRsMConnAtt tDn="uni/infra/mDev-CISCO-ASA-1.2/mFunc-Firewall/mConn-
external"/>
   </vnsAbsFuncConn>

   <!-- This is the name of the connectivity point of the node -->
   <!-- the name is referenced by "AbsNode-ASA-1-node/AbsFConn-ASAnodeinside" -->
   <vnsAbsFuncConn attNotify="no" name="ASAnodeinside">
      <!-- This is the Metadevice information i.e. the mConnector -->
          <!-- "internal" is not an arbitrary name, it is the definition of the
type of interface -->
      <!-- and it has a precise meaning in the meta device -->
      <vnsRsMConnAtt tDn="uni/infra/mDev-CISCO-ASA-1.2/mFunc-Firewall/mConn-
internal"/>
   </vnsAbsFuncConn>
    </vnsAbsNode>

    <!-- Makes it possible to enable routing on the BD that it connects to -->
    <vnsAbsConnection adjType="L3" connType="external" name="ArbitraryName1"
unicastRoute="yes">
    <vnsRsAbsConnectionConns tDn="uni/tn-Sales/AbsGraph-FW-bridged/AbsNode-ASA-1-
node/AbsFConn-ASAnodeoutside"/>
    <vnsRsAbsConnectionConns tDn="uni/tn-Sales/AbsGraph-FW-
bridged/AbsTermNodeCon-OutsideTerminalConnector/AbsTConn"/>
    </vnsAbsConnection>
    <vnsAbsConnection adjType="L2" connType="external" name="ArbitraryName2"
unicastRoute="no">
   <vnsRsAbsConnectionConns tDn="uni/tn-Sales/AbsGraph-FW-bridged/AbsNode-ASA-1-
node/AbsFConn-ASAnodeinside"/>
   <vnsRsAbsConnectionConns tDn="uni/tn-Sales/AbsGraph-FW-
bridged/AbsTermNodeProv-InsideTerminalConnector/AbsTConn"/>
    </vnsAbsConnection>

  </vnsAbsGraph>

  </fvTenant>
</polUni>
```

Configuring Device Selection Policy

```
<polUni>
<fvTenant name="Sales">

 <!-- here we need to match the contract name -->
 <!-- the graph name -->
 <!-- the node name in the graph -->
 <!-- and indicate which interface maps to which BD -->
 <!-- nodeNameOrLbl refers to the name of the node as defined the Abstract Graph
-->
<vnsLDevCtx ctrctNameOrLbl="webtoapp" graphNameOrLbl="FW-bridged"
nodeNameOrLbl="ASA-1-node">

<!-- ASAv01-cluster is the name of the Logical Device i.e. of the Cluster of ASAv
-->
  <vnsRsLDevCtxToLDev tDn="uni/tn-Sales/lDevVip-ASAv01-cluster"/>

  <!-- Connector name is defined in the Abstract Graph -->
  <!-- It is the function connector -->
  <vnsLIfCtx connNameOrLbl="ASAnodeoutside" name="line1">
    <!-- ASAv01-cluster is the name of the Logical Device -->
    <!-- The Lif is the "cluster" interface name, i.e. the abstract interface -->
    <!-- that can map to either ASAv in the cluster -->
    <vnsRsLIfCtxToLIf tDn="uni/tn-Sales/lDevVip-ASAv01-cluster/lIf-
ASAClusterExt"/>
   <!-- This is the outside BD-->
   <vnsRsLIfCtxToBD tDn="uni/tn-Sales/BD-SalesBDOutside"/>
    </vnsLIfCtx>
    <vnsLIfCtx connNameOrLbl="ASAnodeinside" name="line2">
   <vnsRsLIfCtxToLIf tDn="uni/tn-Sales/lDevVip-ASAv01-cluster/lIf-
ASAClusterInt"/>
   <vnsRsLIfCtxToBD tDn="uni/tn-Sales/BD-SalesBDInside"/>
    </vnsLIfCtx>
</vnsLDevCtx>

</fvTenant>
</polUni>
```

Configuring the Provider EPG with L4-L7 Parameters

```
<polUni>
<fvTenant name="Sales">

<!-- Application Profile -->
<fvAp name="orderingtool">

<!-- Inside: app  -->
  <fvAEPg name="app">

   <!-- RELATION TO THE EXTERNAL AND INTERNAL INTERFACES  -->
   <vnsFolderInst ctrctNameOrLbl="webtoapp" graphNameOrLbl="FW-bridged"
key="ExIntfConfigRelFolder" name="ExtConfig" nodeNameOrLbl="ASA-1-node" >
    <vnsCfgRelInst key="ExIntfConfigRel" name="ExtConfigrel"
targetName="externalIf"/>
   </vnsFolderInst>
   <vnsFolderInst ctrctNameOrLbl="webtoapp" graphNameOrLbl="FW-bridged"
key="InIntfConfigRelFolder" name="IntConfig" nodeNameOrLbl="ASA-1-node" >
    <vnsCfgRelInst key="InIntfConfigRel" name="InConfigrel"
targetName="internalIf"/>
   </vnsFolderInst>

   <!-- ACL DEFINITION, ACL NAME "access-list-inbound" -->
   <vnsFolderInst ctrctNameOrLbl="webtoapp" graphNameOrLbl="FW-bridged"
key="AccessList" name="access-list-inbound" nodeNameOrLbl="ASA-1-node" >

   <!-- ACE "permit-ssh" -->
   <vnsFolderInst ctrctNameOrLbl="webtoapp" graphNameOrLbl="FW-bridged"
key="AccessControlEntry" name="permit-ssh" nodeNameOrLbl="ASA-1-node" >
     <vnsParamInst key="order" name="order1"  value="10"/>
    <!-- protocol -->
    <vnsFolderInst ctrctNameOrLbl="webtoapp" graphNameOrLbl="FW-bridged"
key="protocol" name="tcp" nodeNameOrLbl="ASA-1-node" >
   <vnsParamInst key="name_number" name="tcp"  value="tcp"/>
   </vnsFolderInst>
   <!-- source address -->
   <vnsFolderInst ctrctNameOrLbl="webtoapp" graphNameOrLbl="FW-bridged"
key="source_address" name="src-address" nodeNameOrLbl="ASA-1-node" >
   <vnsParamInst key="any" name="any"  value="any"/>
   </vnsFolderInst>
  <!-- destination address -->
   <vnsFolderInst ctrctNameOrLbl="webtoapp" graphNameOrLbl="FW-bridged"
key="destination_address" name="dest-address" nodeNameOrLbl="ASA-1-node" >
   <vnsParamInst key="any" name="any"  value="any"/>
  </vnsFolderInst>
  <!-- destination L4 port -->
  <vnsFolderInst ctrctNameOrLbl="webtoapp" graphNameOrLbl="FW-bridged"
key="destination_service" name="dest-service" nodeNameOrLbl="ASA-1-node" >
   <vnsParamInst key="operator" name="op"  value="eq"/>
   <vnsParamInst key="low_port" name="port"  value="22"/>
  </vnsFolderInst>
   <!-- action permit or deny -->
   <vnsParamInst key="action" name="action-permit"  value="permit"/>
  </vnsFolderInst>
  <!-- ACE "permit-icmp" -->
  <vnsFolderInst ctrctNameOrLbl="webtoapp" graphNameOrLbl="FW-bridged"
key="AccessControlEntry" name="permit-icmp" nodeNameOrLbl="ASA-1-node" >
  <vnsParamInst key="order" name="order1"  value="10"/>
   <!-- protocol -->
   <vnsFolderInst ctrctNameOrLbl="webtoapp" graphNameOrLbl="FW-bridged"
key="protocol" name="icmp" nodeNameOrLbl="ASA-1-node" >
   <vnsParamInst key="name_number" name="icmp"  value="icmp"/>
   </vnsFolderInst>
   <!-- source address -->
   <vnsFolderInst ctrctNameOrLbl="webtoapp" graphNameOrLbl="FW-bridged"
key="source_address" name="src-address" nodeNameOrLbl="ASA-1-node" >
   <vnsParamInst key="any" name="any"  value="any"/>
  </vnsFolderInst>
  <!-- destination address -->
  <vnsFolderInst ctrctNameOrLbl="webtoapp" graphNameOrLbl="FW-bridged"
key="destination_address" name="dest-address" nodeNameOrLbl="ASA-1-node" >
  <vnsParamInst key="any" name="any"  value="any"/>
  </vnsFolderInst>
   <!-- action -->
   <vnsParamInst key="action" name="action-permit"  value="permit"/>
  </vnsFolderInst>
  </vnsFolderInst>


  <!-- BRIDGE-GROUP 1 -->
    <vnsFolderInst  ctrctNameOrLbl="webtoapp"  graphNameOrLbl="FW-bridged"
key="BridgeGroupIntf" name="1" nodeNameOrLbl="ASA-1-node" scopedBy="epg">
    <vnsParamInst  key="ipv6_nd_dad_attempts"  name="ipv6_nd_dad_attempts"
validation="" value="1"/>
    <!-- IP ADDRESS-->
    <vnsFolderInst  ctrctNameOrLbl="webtoapp"  graphNameOrLbl="FW-bridged"
key="IPv4Address" name="IPv4Address" nodeNameOrLbl="ASA-1-node" scopedBy="epg">
    <vnsParamInst  key="ipv4_address"  name="ipv4_address" validation=""
value="30.0.0.254/255.255.255.0"/>
    </vnsFolderInst>
    </vnsFolderInst>


<!-- EXTERNAL INTERFACE  -->
```

```
    <vnsFolderInst ctrctNameOrLbl="webtoapp" graphNameOrLbl="FW-bridged"
key="Interface" name="externalIf" nodeNameOrLbl="ASA-1-node" >
    <vnsFolderInst ctrctNameOrLbl="webtoapp" graphNameOrLbl="FW-bridged"
key="InterfaceConfig" name="externalIfCfg" nodeNameOrLbl="ASA-1-node" >
<!-- BRIDGE-GROUP CONFIGURATION -->
     <vnsCfgRelInst  key="bridge_group"  name="extbridge" targetName="1"/>
     <!-- security level -->
     <vnsParamInst key="security_level" name="external_security_level"
value="50"/>
     </vnsFolderInst>
     <!-- access-group  -->
     <vnsFolderInst ctrctNameOrLbl="webtoapp" graphNameOrLbl="FW-bridged"
key="AccessGroup" name="ExtAccessGroup" nodeNameOrLbl="ASA-1-node" >
     <vnsCfgRelInst key="inbound_access_list_name" name="name"
targetName="access-list-inbound"/>
   </vnsFolderInst>
   </vnsFolderInst>
   <vnsFolderInst ctrctNameOrLbl="webtoapp" graphNameOrLbl="FW-bridged"
key="Interface" name="internalIf" nodeNameOrLbl="ASA-1-node" >
   <vnsFolderInst ctrctNameOrLbl="webtoapp" graphNameOrLbl="FW-bridged"
key="InterfaceConfig" name="internalIfCfg" nodeNameOrLbl="ASA-1-node" >
   <!-- BRIDGE-GROUP CONFIGURATION -->
   <vnsCfgRelInst  key="bridge_group"  name="intbridge" targetName="1"/>
   <!-- security level -->
   <vnsParamInst key="security_level" name="internal_security_level"
value="100"/>
   </vnsFolderInst>
   </vnsFolderInst>
  </fvAEPg>
</fvAp>
  </fvTenant>
</polUni>
```

Attaching the Graph to the Contract

```
<polUni>
<fvTenant name="Sales">
<vzBrCP name="webtoapp">
   <vzSubj name="alltraffic" provMatchT="AtleastOne" revFltPorts="yes">
   <vzRsSubjFiltAtt tnVzFilterName="default"/>
   <vzRsSubjGraphAtt tnVnsAbsGraphName="FW-bridged"/>
   </vzSubj>
</vzBrCP>
</fvTenant>
</polUni>
```

Conclusion

Cisco ACI enables you to automate the provisioning of L4-L7 network connectivity and L4-L7 configurations in the data center. It also enables you to insert L4-L7 devices in the traffic path while keeping the Cisco ACI fabric as the default gateway for the servers.

Cisco ACI can also be used to configure the L4-L7 device for the entirety of the configuration or for only the networking portion.

Three operational models are available:

- Network policy mode, for cases in which the L4-L7 device is managed by a different administrator and Cisco ACI should configure only network connectivity
- Service policy mode, for full automation through the APIC
- Service manager mode, for cases in which the APIC administrator defines the networking configuration of the L4-L7 device through the APIC while the L4-L7 administrator defines the L4-L7 policy through a different management tool

These functions can be implemented using the GUI or programmatically in Python and can be automated using the REST API.

For More Information

For more information about Cisco ACI and service graphs, please refer to:

- https://www.cisco.com/go/aci
- https://www.cisco.com/c/en/us/solutions/data-center-virtualization/unified-fabric/aci_ecosystem.html.

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