Cisco Cloud Network Controller Policy Model

About the CCNC Policy Model

The CCNC policy model enables the specification of application requirements policies. The Cisco Cloud Network Controller automatically renders policies in the cloud infrastructure. When you or a process initiates an administrative change to an object in the cloud infrastructure, the Cisco Cloud Network Controller first applies that change to the policy model. This policy model change then triggers a change to the actual managed item. This approach is called a model-driven framework.

Policy Model Key Characteristics

Key characteristics of the policy model include the following:

- As a model-driven architecture, the software maintains a complete representation of the administrative and operational state of the system (the model). The model applies uniformly to cloud infrastructure, services, system behaviors, and virtual devices attached to the network.
- The logical and concrete domains are separated; the logical configurations are rendered into concrete configurations by applying the policies in relation to the available resources. No configuration is carried

out against concrete entities. Concrete entities are configured implicitly as a side effect of the changes to the Cisco Cloud policy model.

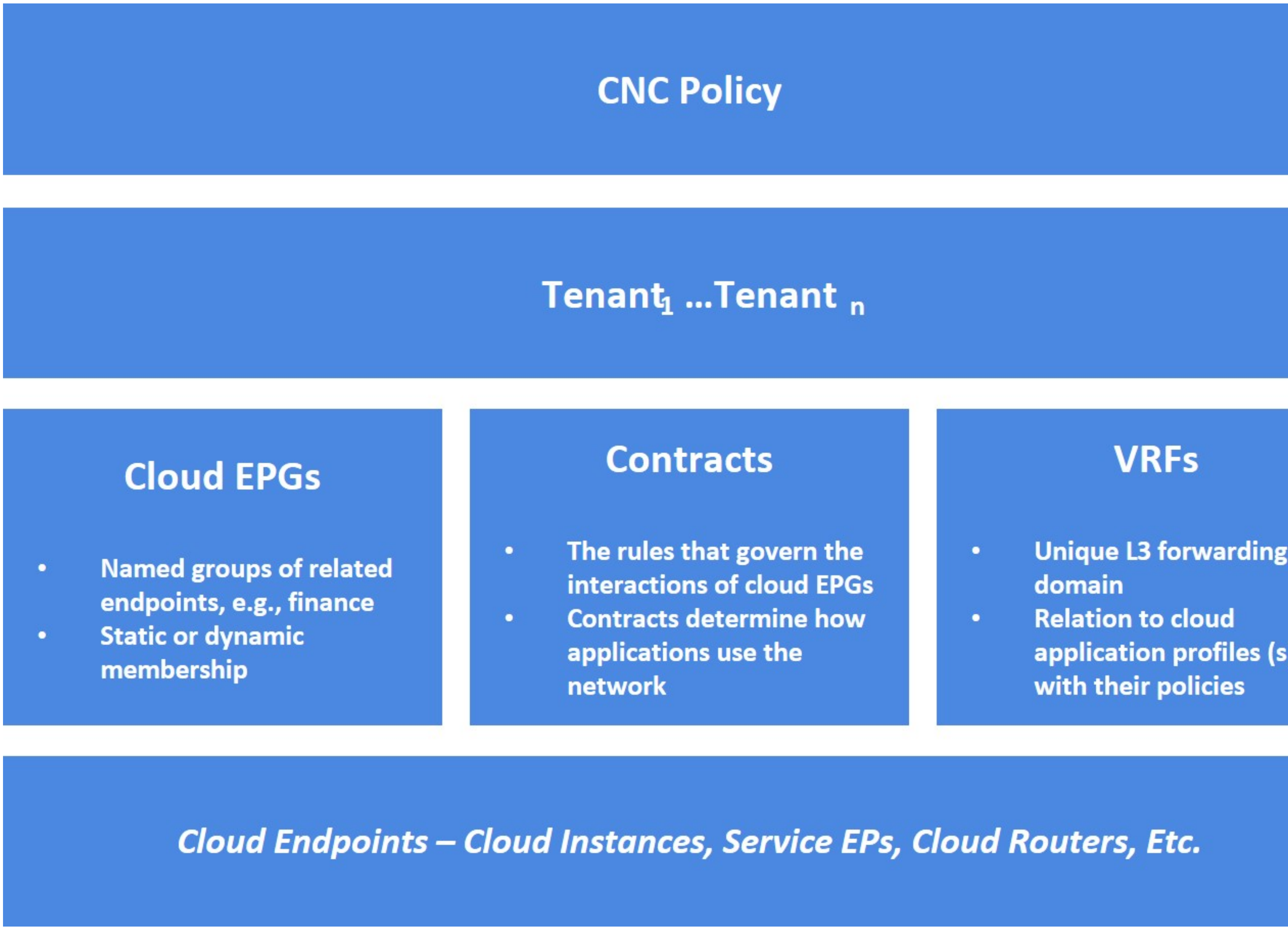
- The system prohibits communications with newly connected endpoints until the policy model is updated to include the new endpoint.
- Network administrators do not configure logical system resources directly. Instead, they define logical (hardware-independent) configurations and the Cisco Cloud Network Controller policies that control different aspects of the system behavior.

Managed object manipulation in the model relieves engineers from the task of administering isolated, individual component configurations. These characteristics enable automation and flexible workload provisioning that can locate any workload anywhere in the infrastructure. Network-attached services can be easily deployed, and the Cisco Cloud Network Controller provides an automation framework to manage the lifecycle of those network-attached services.

Logical Constructs

The policy model manages the entire cloud infrastructure, including the infrastructure, authentication, security, services, applications, cloud infrastructure, and diagnostics. Logical constructs in the policy model define how the cloud infrastructure meets the needs of any of the functions of the cloud infrastructure. The following figure provides an overview of the CCNC policy model logical constructs.

Figure 1: CCNC Policy Model Logical Constructs Overview


CNC Policy
Tenant1 ...Tenant n
Cloud EPGs
• Named groups of related endpoints, e.g., finance
• Static or dynamic membership
Contracts
• The rules that govern the interactions of cloud EPGs
• Contracts determine how applications use the network
VRFs
• Unique L3 forwarding domain
• Relation to cloud application profiles (s with their policies
Cloud Endpoints – Cloud Instances, Service EPs, Cloud Routers, Etc.

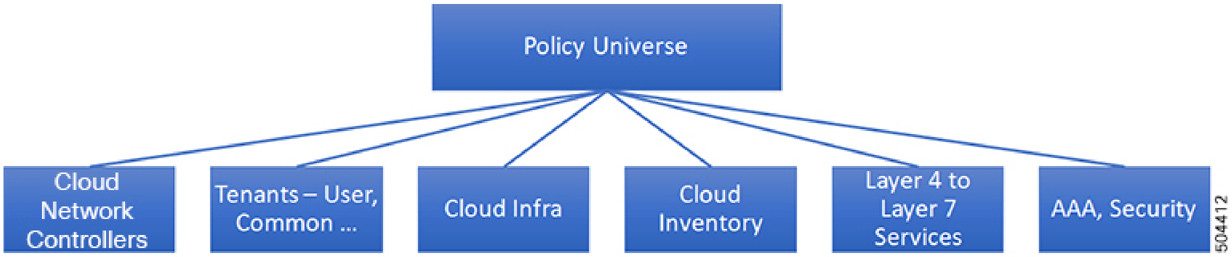
Certain administrators (tenant or cloud infrastructure-wide) create predefined policies that contain application or shared resource requirements. These policies automate the provisioning of applications, network-attached services, security policies, and tenant subnets, which puts administrators in the position of approaching the resource pool in terms of applications rather than infrastructure building blocks. The application needs to drive the networking behavior, not the other way around.

The Cisco CCNC Policy Management Information Model

The cloud infrastructure comprises the logical components as recorded in the Management Information Model (MIM), which can be represented in a hierarchical management information tree (MIT). The Cisco Cloud Network Controller runs processes that store and manage the information model. Similar to the OSI Common Management Information Protocol (CMIP) and other X.500 variants, the Cisco Cloud Network Controller enables the control of managed resources by presenting their manageable characteristics as object properties that can be inherited according to the location of the object within the hierarchical structure of the MIT.

Each node in the tree represents a managed object (MO) or group of objects. MOs are abstractions of cloud infrastructure resources. An MO can represent a concrete object, such as a cloud router, adapter, or a logical object, such as an application profile, cloud endpoint group, or fault. The following figure provides an overview of the MIT.

Figure 2: Cisco CCNC Policy Management Information Model Overview


Policy Universe
Cloud Network Controllers
Tenants – User, Common ...
Cloud Infra
Cloud Inventory
Layer 4 to Layer 7 Services
AAA, Security
504412

The hierarchical structure starts with the policy universe at the top (Root) and contains parent and child nodes. Each node in the tree is an MO and each object in the cloud infrastructure has a unique distinguished name (DN) that describes the object and locates its place in the tree.

The following managed objects contain the policies that govern the operation of the system:

- A tenant is a container for policies that enable an administrator to exercise role-based access control. The system provides the following four kinds of tenants:
  - The administrator defines user tenants according to the needs of users. They contain policies that govern the operation of resources such as applications, databases, web servers, network-attached storage, virtual machines, and so on.
  - Although the system provides the common tenant, it can be configured by the cloud infrastructure administrator. It contains policies that govern the operation of resources accessible to all tenants, such as firewalls, load balancers, Layer 4 to Layer 7 services, intrusion detection appliances, and so on.

Note The Cisco Cloud Network Controller only supports load balancers as a Layer 4 to Layer 7 service.

  - The infrastructure tenant is provided by the system but can be configured by the cloud infrastructure administrator. It contains policies that govern the operation of infrastructure resources. It also enables a cloud infrastructure provider to selectively deploy resources to one or more user tenants. Infrastructure tenant policies are configurable by the cloud infrastructure administrator.

- The cloud infra policies enable you to manage on-premises and inter-region connectivity when setting up the Cisco Cloud Network Controller. For more information, see the *Cisco Cloud Network Controller Installation Guide*.
- Cloud inventory is a service that enables you to view different aspects of the system using the GUI. For example, you can view the regions that are deployed from the aspect of an application or the applications that are deployed from the aspect of a region. You can use this information for cloud resource planning and troubleshooting.

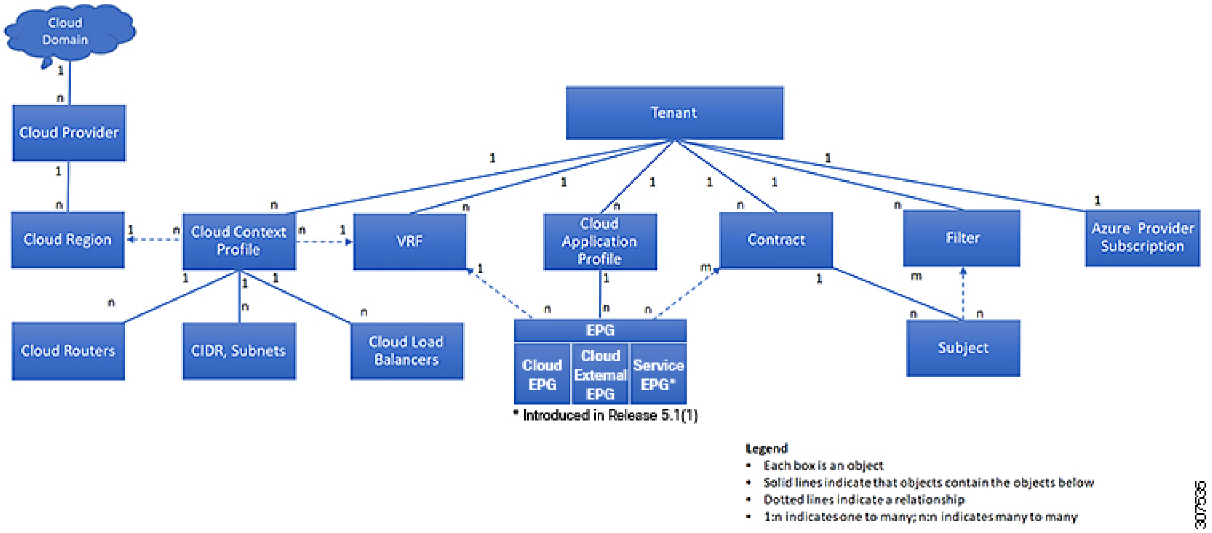
- Layer 4 to Layer 7 service integration lifecycle automation framework enables the system to dynamically respond when a service comes online or goes offline. For more information, see Deploying Layer 4 to Layer 7 Services
- Access, authentication, and accounting (AAA) policies govern user privileges, roles, and security domains of the Cisco Cloud Network Controller cloud infrastructure. For more information, see Cisco Cloud Network Controller Security

The hierarchical policy model fits well with the REST API interface. When invoked, the API reads from or writes to objects in the MIT. URLs map directly into distinguished names that identify objects in the MIT. Any data in the MIT can be described as a self-contained structured tree text document encoded in XML or JSON.

Tenants

A tenant (`fvTenant`) is a logical container for application policies that enable an administrator to exercise domain-based access control. A tenant represents a unit of isolation from a policy perspective, but it does not represent a private network. Tenants can represent a customer in a service provider setting, an organization or domain in an enterprise setting, or just a convenient grouping of policies. The following figure provides an overview of the tenant portion of the management information tree (MIT).

Figure 3: Tenants


Cloud Domain
Cloud Provider
Cloud Region
Cloud Context Profile
VRF
Tenant
Cloud Application Profile
Contract
Filter
Azure Provider Subscription
Cloud Routers
CIDR, Subnets
Cloud Load Balancers
EPG
Cloud EPG
Cloud External EPG
Service EPG*
Subject
1
n
m
* Introduced in Release 5.1(1)
Legend
Each box is an object
Solid lines indicate that objects contain the objects below
Dotted lines indicate a relationship
1:n indicates one to many; n:n indicates many to many
307535

Tenants can be isolated from one another or can share resources. The primary elements that the tenant contains are filters, contracts, Virtual Routing and Forwarding (VRF) instances, cloud context profiles, Azure provider configurations, and cloud application profiles that contain cloud endpoint groups (cloud EPGs). Entities in the tenant inherit its policies. VRFs are also known as contexts; each VRF can be associated with multiple cloud context profiles. A cloud context profile, in conjunction with a VRF, tenant and region, represents a resource group in Azure. A VNET is created inside the resource group based on the VRF name.

Tenants are logical containers for application policies. The cloud infrastructure can contain multiple tenants. You must configure a tenant before you can deploy any Layer 4 to Layer 7 services. The CCNC cloud infrastructure supports only IPv4 configurations for tenant networking.

Support for Multiple Cloud Subscriptions Under a Single Tenant

Beginning with 26.0(2), multiple cloud subscriptions can be associated to a given tenant and deploy different cloud resources in multiple Azure cloud subscriptions. Different VNets can also be deployed in different subscriptions under the same VRF for a given tenant.

For example, if you have only cloud deployments where cloud resources have to be deployed in different cloud accounts, you can now create a tenant that has multiple accounts and then have VNets point to the respective cloud subscriptions.

Note Multi-Account tenant is only suppported on cloud deployments. This is not supported on configurations deployed in Nexus Dashboard Orchestrator.

Understanding Tenants, Identities, and Subscriptions

Azure has an active directory structure. The top level structure is the organization, and underneath the organization are the directories (also known as Azure tenants). Inside the directories, you can have one or more Azure subscriptions.

The relationship between certain Azure components is as follows:

Tenants > **Subscriptions** > **Resource Groups** > **Resources**

Where:

- One tenant can have multiple subscriptions, but each subscription can belong to only one tenant
- One subscription can have multiple resource groups, but each resource group can belong to only one subscription
- One resource group can have multiple resources, but each resource can belong to only one subscription

The following sections provide more detail about each of these components:

- Mapping Azure and Cisco Cloud Network Controller Components, on page 6
- About Azure Subscriptions, on page 6
- About Tenants and Identities, on page 7

Mapping Azure and Cisco Cloud Network Controller Components

In Cisco Cloud Network Controller, each Azure resource group is mapped to one Cisco Cloud Network Controller tenant, and one Cisco Cloud Network Controller tenant can have multiple Azure resource groups.

The relationship between certain Cisco Cloud Network Controller components is as follows:

Tenants > **VRFs** > **Regions**

When you create a VRF in Cisco Cloud Network Controller, a new resource group is also created on Azure.

About Azure Subscriptions

An Azure subscription is used to pay for Azure cloud services. An Azure subscription has a trust relationship with Azure Active Directories (Azure ADs), where the subscription uses the Azure AD to authenticate users, services, and devices. While multiple subscriptions can trust the same Azure AD, each subscription can trust only one Azure AD.

In Azure, the same Azure subscription ID can be used for multiple CCNC tenants. This means that you could configure the infra tenant using one Azure subscription, and then configure more user tenants in the same subscription. CCNC tenants are tied to Azure subscriptions.

About Tenants and Identities

Following are the different types of tenants and identities available through Azure and Cisco Cloud Network Controller.

Note Both managed identity and service principal is supported as an access type for the infra tenants and the user tenants.

Managed Identity

Managed identities provide an identity for applications to use when connecting to resources that support Azure AD authentication. Applications can use the managed identity to obtain Azure AD tokens. For example, an application could use a managed identity to access resources like Azure Key Vault, where developers can store credentials in a secure manner or to access storage accounts.

Following are several benefits to using managed identities:

- You don't need to manage credentials, since credentials are not even accessible to you.
- You can use managed identities to authenticate to any resource that supports Azure AD authentication, including your own applications.
- Managed identities can be used without any additional cost.

For additional information on managed identities in Azure, see:

https://docs.microsoft.com/en-us/azure/active-directory/managed-identities-azure-resources/overview

If you are configuring tenants in the Cisco Cloud Network Controller using **managed identity**, then you will make the following configurations in the Azure portal and in the Cisco Cloud Network Controller:

1. In the Azure portal, you will add a role assignment for a **virtual machine**. You use this option when the Azure subscriptions are in the same Azure directory (of the same organization).

   Note If your Azure subscriptions are in different directories and you want to configure tenants using **managed identity**, you can go to the Azure console and click on each of the subscriptions and move the subscriptions under the same Azure directory. You can only do this if the directories (containing the different subscriptions) are a child of the same parent organization.

2. In the Cisco Cloud Network Controller, you will choose the **Managed Identity** option when configuring a tenant in Cisco Cloud Network Controller.

See Creating a Tenant Using the Cisco Cloud Network Controller GUI for more information on making these configurations.

Service Principal

An Azure **service principal** is an identity created for use with applications, hosted services, and automated tools to access Azure resources. You would use the service principal identity when you want to configure tenants in different subscriptions. The subscriptions are either in different Azure directories (Azure tenants) in the same organization, or the subscriptions can be in different organizations.

If you are configuring tenants in the Cisco Cloud Network Controller using **service principal**, then you will make the following configurations in the Azure portal and in the Cisco Cloud Network Controller:

1. In the Azure portal, you will be adding a role assignment for an **app**, where the cloud resources will be managed through a specific application.
2. In the Cisco Cloud Network Controller, you will choose the **Service Principal** option when configuring a tenant in Cisco Cloud Network Controller. The subscriptions that you enter in this page can be in different Azure directories (Azure tenants) in the same organization, or the subscriptions can be in different organizations.

See Creating a Tenant Using the Cisco Cloud Network Controller GUI for more information on making these configurations.

Shared Tenant

You will choose this option when you have already associated Azure subscriptions with either of the two methods above and want to create more tenants in that subscription.

If you are configuring a tenant in the Cisco Cloud Network Controller as **shared tenant**, then you will make the following configurations in the Azure portal and in the Cisco Cloud Network Controller:

1. You do not have to make any configurations in Azure specifically for a shared tenant, because you will have already associated Azure subscriptions with either of the two methods above. With the shared tenant, you will just create more tenants in that existing subscription.
2. In the Cisco Cloud Network Controller, you will choose the **Shared** option when configuring a tenant in Cisco Cloud Network Controller.

See Creating a Tenant Using the Cisco Cloud Network Controller GUI for more information on making these configurations.

Support for Inter-Tenant Shared Services in Hybrid Cloud Environments

In Cisco APIC, a pre-defined tenant (the tenant `common`) is available to provide common services to all tenants, such as shared L3Out, private networks, DNS, DHCP, and Active directory. Prior to release 26.0(3), endpoints on an on-premises ACI tenant and endpoints in a user tenant using networking resources from the on-premises tenant `common` cannot communicate with endpoints on the cloud user tenant. Beginning with release 26.0(3), support is now available for inter-tenant shared services between the on-premises tenant `common` and cloud user tenants.

Cisco Cloud Network Controller, used in conjunction with Nexus Dashboard Orchestrator, supports inter-tenant shared services in a hybrid cloud environment, allowing you to deploy resources in on-premises tenants and cloud tenants, where contracts are deployed in tenant `common`. The tenant `common` still exists on the Cloud Network Controller; however, it is not associated with any cloud account. It is just used for storing filters and contracts that later can be used for a shared service policy. Beginning with release 26.0(3), support is available for having resources in the on-premises Cisco APIC tenant `common` for both Application EPGs and external EPGs, as well as having inter-tenant shared services in a hybrid cloud environment.

For example, assume that you already have an on-premises Cisco APIC tenant `common` deployed with a VRF. You can have bridge domain or EPG in the tenant `common` as you normally would, or you can now create a new user tenant to leverage the VRF and bridge domain in the tenant `common`.

Prior to release 26.0(3), the following variants of standard tenant are supported:

- Regular EPG in a user tenant to a cloud tenant
- External EPG in a user tenant to a cloud tenant

With this update in release 26.0(3), the following variants of the on-premises ACI tenant `common` are also supported:

- Regular EPG in the tenant `common` to a cloud tenant
- External EPG in the tenant `common` to a cloud tenant
- Regular EPG in a user tenant with a bridge domain and VRF in the tenant `common` to a cloud tenant
- External EPG in a user tenant with a VRF in the tenant `common` to a cloud tenant

Use Cases

This section describes several use case examples related to the support for inter-tenant shared services in hybrid cloud environments in release 26.0(3).

On-Premises Cisco APIC Tenant Common Use Case

In this use case, an on-premises Cisco APIC tenant `common` is deployed with either or both of these configurations:

- Application EPGs in the bridge domain or subnet
- External EPG subnet in the L3Out

There is also a contract configured with a user tenant in a cloud site.

The user tenant in the cloud site can be stretched to all the sites, including the on-premises and other cloud sites, and traffic will still flow between the on-premises tenant `common` and the user tenant across all sites.

Site1: On-Premises Site	Site2: Cloud Site
VRF in tenant `common` in Site1: VRF1	VRF in tenant in Site2: VRF2
EPG in Site1: EPG1	EPG in Site2: EPG2
Tenant in Site2 stretched to Site1	Tenant `common` in Site1 available in Site2
External EPG available in VRF1 in tenant `common`	External EPG can be created on Site1

Site User Tenants Use Case

In this use case, a tenant (Tenant1) is deployed only in Site1, which is either an on-premises site or a cloud site, and another tenant (Tenant2) is deployed only in Site2, which is a cloud site, and a contract is shared across tenants.

Site1: On-Premises or Cloud Site	Site2: Cloud Site
VRF in tenant (Tenant1) in Site1: VRF1	VRF in tenant (Tenant2) in Site2: VRF2
EPG in Site1: EPG1	EPG in Site2: EPG2
Tenant2 in Site2 stretched to Site1	Tenant1 in Site1 stretched to Site2
External EPG available in VRF1 in Tenant1	External EPG can be created on Site1

Example Configuration Process

The following general steps provide an example for configuring inter-tenant shared services in hybrid cloud environments. See the Nexus Dashboard Orchestrator documentation for more details.

1. Define the tenants, if necessary.

   In this example scenario, two tenants need to be defined:

   - Cloud only tenant that is associated with a cloud account
   - On-premises `common` tenant, which is already defined through APIC and exists in both the on-premises ACI and the cloud by default

2. Define the tenant templates in Nexus Dashboard Orchestrator (NDO) that are associated with the two tenants.

   In this example scenario, you will define two tenant templates in NDO:

   - `cloud-tenant-template`: Tenant template that is associated with the cloud only tenant
   - `common-tenant-template`: Tenant template that is associated with the on-premises `common` tenant

3. Create a schema (for example, `common-schema`) with the necessary templates.

   You can have multiple templates within a schema. For example, you could create two templates within this schema:

   - `common-policy`: In this example scenario, we will make the following configurations in this template:
     - We will associate this template with the `common` tenant in the cloud site. This template is to deploy the contracts and filter to the `common` tenant on the cloud (though the `common` tenant is not associated with any cloud account) and the `common` tenant on the on-premises ACI site.
     - We will also create two contracts in this template:
       - One for the external EPG from the on-premises site to the cloud site
       - One for a regular EPG from the on-premises site to the cloud site
     - We will also configure the necessary policy contract and filters within this template.
   - `common-app`: In this example scenario, we will associate this template only with the tenant `common` in the on-premises site, and we will make the necessary configurations with this on-premises site, such as configurations related to an application profile, VRF, bridge domain, L3Out, external EPG, and so on.

4. Create a second schema (for example, `cloud-schema`) with a single template (`cloud-only`), where we will associate this template only with the cloud only tenant, and we will make the necessary configurations with this cloud site, such as configuruations related to an application profile, VNet/vPC, and so on.
5. Configure contracts using the contracts that you defined when you created the schemas.
6. Deploy the configurations in NDO.

Cloud Context Profile

The cloud context profile contains information on the following Cisco Cloud Network Controller components:

- CIDRs
- VRFs
- EPGs
- Regions
- Virtual Networks
- Routers
- Endpoints

CCR

The CCR is a virtual router that delivers comprehensive WAN gateway and network services into virtual and cloud environments. The CCR enables enterprises to extend their WANs into provider-hosted clouds. Two CCRs are required for Cisco Cloud Network Controller solution.

The **Cisco Catalyst 8000V** is used with the Cisco Cloud Network Controller. For more information on this type of CCR, see the Cisco Catalyst 8000V Edge software documentation.

About the Cisco Catalyst 8000V

Following are the updates in the Cisco Catalyst 8000V.

Note Cisco Catalyst 8000V needs to be upgraded to version **17.12.02** using existing upgrade procedure when Cisco Cloud Network Controller gets upgraded to version **26.0(3)** . View Triggering an Upgrade of the C8kVs to upgrade Cisco Catalyst 8000V.

- Licensing Models, on page 11
- Throughput Options Based on Licensing Models, on page 12

Licensing Models

The Cisco Catalyst 8000V on Cisco Cloud Network Controller supports two licensing models:

1. **Bring Your Own License (BYOL)**
2. **Pay As You Go (PAYG)**

BYOL Licensing Model

The BYOL licensing model on Cisco Catalyst 8000V which requires you to purchase your Catalyst 8000V Cisco DNA license from Cisco and deploy it in the cloud.

- For instructions on subscribing to one of the tier-based Cisco Catalyst 8000V licenses, see the Cisco Catalyst 8000V Edge Software.
- For more information on different throughputs based on the tiers, see Throughput Options Based on Licensing Models, on page 12.

Cisco Cloud Network Controller makes use of the "Cisco DNA Advantage" subscription. For features supported by the "Cisco DNA Advantage" subscription, see the Cisco DNA Software SD-WAN and Routing Matrices.

PAYG Licensing Model

Cisco Cloud Network Controller supports Pay-As-You-Go (PAYG) Licensing Model on Cisco Catalyst 8000V which allows users to deploy a Catalyst 8000V instance in the cloud based on the VM size and purchase the usage on an hourly basis.

As you completely depend on the VM size to get the throughput, the PAYG licensing model can be enabled only by first un-deploying the current Cisco Catalyst 8000V and then re-deploying it using the First Time Set Up with the new VM size. For more information, see "Configuring Cisco Cloud Network Controller Using the Setup Wizard" in the *Cisco Cloud Network Controller for Azure Installation Guide*

Note The procedure for switching between licenses can also be used if you would like to switch between the two licensing types available.

Note There are two PAYG options for consuming licenses in the Azure marketplace: **Catalyst 8000V Cisco DNA Essentials** and **Catalyst 8000V Cisco DNA Advantage**. Cisco Cloud Network Controller will make use of **Catalyst 8000V Cisco DNA Advantage**. For features supported by the "Cisco DNA Advantage" subscription, see Cisco DNA Software SD-WAN and Routing Matrices

Throughput Options Based on Licensing Models

The Cisco Catalyst 8000V on Cisco Cloud Network Controller supports two licensing models:

1. **Bring Your Own License (BYOL)**
2. **Pay As You Go (PAYG)**

1. Bring Your Own License (BYOL)

For this model, the Cisco Catalyst 8000V supports tier-based (T0/T1/T2/T3) throughput options. The following table lists what Azure VM sizes are needed for different router throughput settings for the Cisco Catalyst 8000V:

CCR Throughput	Azure VM Size
T0 (up to 15M throughput)	DS3_v2
T1 (up to 100M throughput)	DS3_v2
T2 (up to 1G throughput)	DS3_v2
T3 (up to 10G throughput)	F16s_v2

Tier2 (T2) is the default throughput supported by Cisco Cloud Network Controller.

2. Pay-As-You-Go Licensing Model

For this model, Cisco Cloud Network Controller supports a range of Azure compute instances for cloud networking needs powered by Cisco's Catalyst 8000V virtual router.

The table below shows the cloud instance type supported by Cisco Cloud Network Controller on Azure.

VmName on Azure	Memory	vCPUs	NetworkBw
DS3V2	14GiB	4	Up to 3 Gigabit
DS4V2	28GiB	8	Up to 6 Gigabit
F16SV2	32GiB	16	Up to 12.5 Gigabit
F32SV2	64GiB	32	Up to 16 Gigabit

Changing the Number of CCRs

The maximum number of CCRs supported per region increased from 4 to 8. These procedures provide instructions for increasing the number of CCRs above 4, or for reducing the number of CCRs back to 4, if necessary.

Note the following:

- You do not have to use these instructions if you are increasing or decreasing the number of CCRs in a range between 2-4 CCRs. Use these instructions only if you are increasing the number of CCRs above 4, or if you are decreasing the number of CCRs from a range of 5-8 CCRs.
- Changing the number of CCRs can impact traffic for up to 30 minutes.

Step 1 Disable Azure VNet peering at the local level on all infra cloud context profiles.

a) Navigate to the **Create Cloud Context Profile** page:

Application Management > **Cloud Context Profiles**

b) Click the link under the **Name** column for the infra cloud context profile.

A panel showing details for this cloud context profile slides in from the right side of the window.

c) Click the Details icon (↗).

Another window appears that provides more detailed information for this cloud context profile.

d) Click the pencil icon in the upper right corner of the window.

The **Edit Cloud Context Profile** window appears.

e) Uncheck (disable) the **Hub Network Peering** field.
f) Click **Save** when finished.

Repeat these steps to disable Azure VNet peering on all infra cloud context profiles.

Step 2 If you are increasing the number of CCRs above 4, add additional subnet pools for the additional CCRs, if necessary.

You will see an error message is you attempt to increase the number of CCRs above 4 and the system determines that additional subnet pools are required.

a) In the Cisco Cloud Network Controller GUI, click the Intent icon ( ) and select **Cloud Network Controller Setup**.
b) In the **Region Management** area, click **Edit Configuration**.
c) In the **Regions to Manage** window, click **Next**.

The **General Connectivity** window appears.

d) Under the **General** area, in the **Subnet Pools for Cloud Routers** field, click **Add Subnet Pool for Cloud Routers** if you want to add additional subnets for CCRs.

Addresses from this subnet pool will be used for inter-region connectivity for any additional regions that are added that need to be managed by the Cisco Cloud Network Controller. This must be a valid IPv4 subnet with mask /24.

Step 3 Increase the number of CCRs above 4, or decrease the number of CCRs from a range of 5-8 CCRs.

a) In your Cisco Cloud Network Controller GUI, click the Intent icon ( ) and choose **Cloud Network Controller Setup**.
b) In the **Region Management** area, click **Edit Configuration**.

The **Regions to Manage** window appears.

c) Click **Next** to leave the previously-selected regions and CCRs as-is.

The **General Connectivity** window appears.

d) Locate the **CCRs** area in the **General Connectivity** window and, in the **Number of Routers Per Region** field, make the necessary changes to increase or decrease the number of CCRs.
e) Click **Next**, then enter the necessary information in the following page and click **Save and Continue**.

The process of adding or removing the CCRs might take roughly a half hour.

Step 4 Enable Azure VNet peering again at the local level on all infra cloud context profiles.

a) Navigate to the **Create Cloud Context Profile** page:

Application Management > **Cloud Context Profiles**

b) Click the link under the **Name** column for the infra cloud context profile.

A panel showing details for this cloud context profile slides in from the right side of the window.

c) Click the Details icon ().

Another window appears that provides more detailed information for this cloud context profile.

d) Click the pencil icon in the upper right corner of the window.

The **Edit Cloud Context Profile** window appears.

e) Check (enable) the **Hub Network Peering** field.
f) Click **Save** when finished.

Repeat these steps to enable Azure VNet peering on all infra cloud context profiles.

Private IP Address Support for Cisco Cloud Network Controller and CCR

By default, CCR interfaces are assigned private IP addresses only and assignment of public IP addresses to CCR interfaces is optional. Private IP addresses are always assigned to all the interfaces of a CCR. The private IP of GigabitEthernet1 of a CCR is used as BGP and OSPF router IDs. Hybrid cloud with on-premise ACI sites over express route is supported when CCRs are assigned private IP addresses.

To enable CCR private IP addresses for inter-site connectivity, where you are disabling public IP addresses for the CCR interfaces, see the Managing Regions (Configuring a Cloud Template) Using the Cisco Cloud Network Controller GUI procedure.

By default, a private IP address is assigned to the management interface of the Cisco Cloud Network Controller and assigning a public IP address is optional. To disable public IP to the Cisco Cloud Network Controller so that a private IP address is used for connectivity, see *Deploying the Cisco Cloud Network Controller in Azure* procedure in the *Cisco Cloud Network Controller for Azure Installation Guide*.

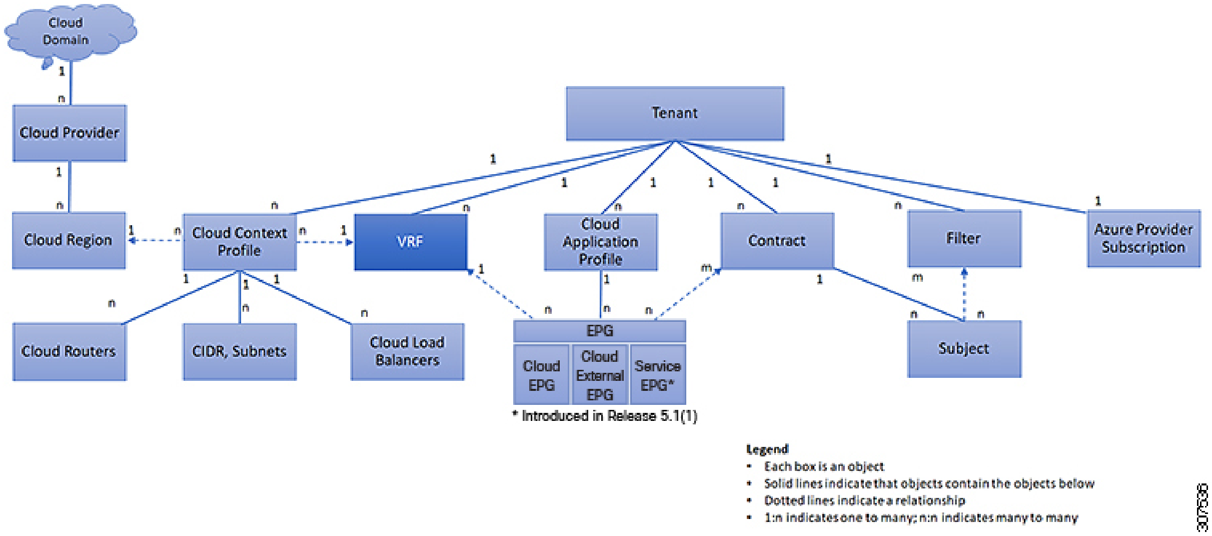
Restrictions for CCR with Private IP Address:

- No support for multicloud deployments as intersite communication needs IPsec.

VRFs

A Virtual Routing and Forwarding (VRF) object (`fvCtx`) or context is a tenant network (called a VRF in the Cisco Cloud Network Controller GUI). A tenant can have multiple VRFs. A VRF is a unique Layer 3 forwarding and application policy domain. The following figure shows the location of VRFs in the management information tree (MIT) and their relation to other objects in the tenant.

Figure 4: VRFs


Cloud Domain
Cloud Provider
Cloud Region
Cloud Context Profile
VRF
Tenant
Cloud Application Profile
Contract
Filter
Azure Provider Subscription
Cloud Routers
CIDR, Subnets
Cloud Load Balancers
EPG
Cloud EPG
Cloud External EPG
Service EPG*
Subject
* Introduced in Release 5.1(1)
Legend
Each box is an object
Solid lines indicate that objects contain the objects below
Dotted lines indicate a relationship
1:n indicates one to many; n:n indicates many to many
307536

A VRF defines a Layer 3 address domain. One or more cloud context profiles are associated with a VRF. You can only associate one cloud context profile with a VRF in a given region. All the endpoints within the Layer 3 domain must have unique IP addresses because it is possible to forward packets directly between these devices if the policy allows it. A tenant can contain multiple VRFs. After an administrator creates a logical device, the administrator can create a VRF for the logical device, which provides a selection criteria policy for a device cluster. A logical device can be selected based on a contract name, a graph name, or the function node name inside the graph.

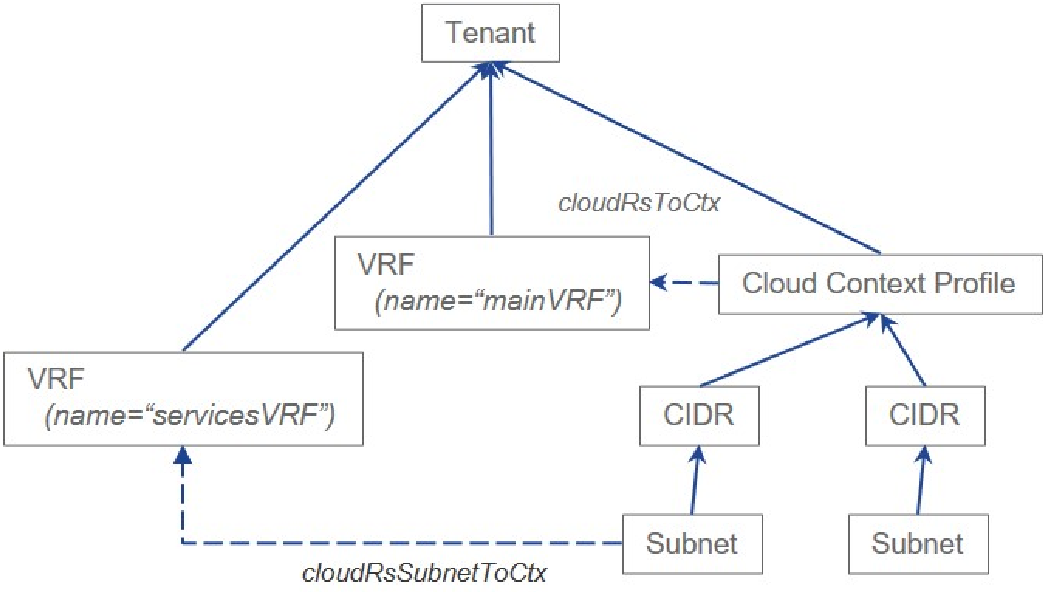
Support for Multiple VRFs Under Single VNet

Support is now available for multiple VRFs under a single VNet.

You can have an infra (hub) VNet (a `cloudCtxProfile` in the infra tenant) that can be carved out into multiple VRFs. All subnets in the respective VRFs will have separate route tables in the cloud for VRF segregation.

You can also carve out multiple VRFs beyond the infra VNet so that you can divide any VNet into multiple VRFs under the same tenant, where multiple VRFs can exist in a single VNet. This is useful for situations such as cloud service access, where you might want to carve out multiple networks (VRFs) within a given VNet, allowing you to have separate routing by having unique route tables for each VRF within the VNet in the cloud.

The following graphic shows an example manged object (MO) relationship tree with multiple VRFs under the same tenant (VNet).



In this example, two VRFs exist under the same tenant (VNet):

- The primary VRF with the name `mainVRF`
- A secondary VRF with the name `servicesVRF`

A second CIDR block and subnet exists in the same cloud context profile, under the same tenant (VNet), but that second CIDR block and subnet is associated with the secondary VRF in that same VNet.

Support for VRF to span across multiple VNets within a Region

Prior to 26.0(2), multiple VNets belonging to the same VRF would need to be deployed in different regions. Beginning with 26.0(2), Cisco Cloud Network Controller will have the ability to configure multiple VNets in a VRF inside one region. This helps enable automatic route propogation across all the VNets grouped under one VRF.

The advantages are as follows :

- This is necessary in situations where a customer may want multiple VNets configured in the same VRF.
- This is also beneficial in cases if the customer wants multiple VNets in the same region. Prior to this feature, the customer would have to deploy the VNets in different VRFs and setup contracts and leak routes to allow communication of the VPCs with each other. This feature helps simplify the configuration.

Note VNets with overlapping subnets cannot be associated with a single VRF in a region. This applies to brownfield VNets as well.

As VNets are created in resource groups, there are two options that are available :

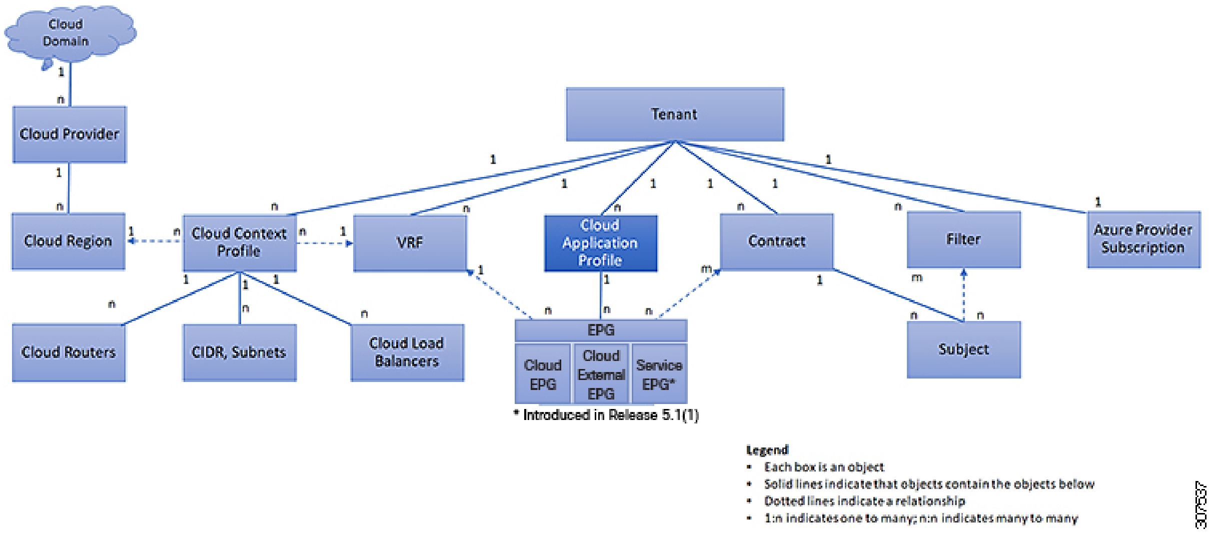
- VNets in the same Resource Group (Greenfield deployments cannot be done using this) - Route tables, ASGs and VNets should have different names to distinguish between cloud context profiles.

- VNets in different Resource Groups (Greenfield deployments can be only be done using this) - Resource groups should have different names in cloud for brownfield resource groups.

Cloud Application Profiles

A cloud application profile (`cloudAp`) defines the policies, services and relationships between cloud EPGs. The following figure shows the location of cloud application profiles in the management information tree (MIT) and their relation to other objects in the tenant.

Figure 5: Cloud Application Profiles


Cloud Domain
Cloud Provider
Cloud Region
Cloud Context Profile
VRF
Tenant
Cloud Application Profile
Contract
Filter
Azure Provider Subscription
Cloud Routers
CIDR, Subnets
Cloud Load Balancers
EPG
Cloud EPG
Cloud External EPG
Service EPG*
Subject
* Introduced in Release 5.1(1)
Legend
• Each box is an object
• Solid lines indicate that objects contain the objects below
• Dotted lines indicate a relationship
• 1:n indicates one to many; n:n indicates many to many
307537

Cloud application profiles contain one or more cloud EPGs. Modern applications contain multiple components. For example, an e-commerce application could require a web server, a database server, data located in a storage service, and access to outside resources that enable financial transactions. The cloud application profile contains as many (or as few) cloud EPGs as necessary that are logically related to providing the capabilities of an application.

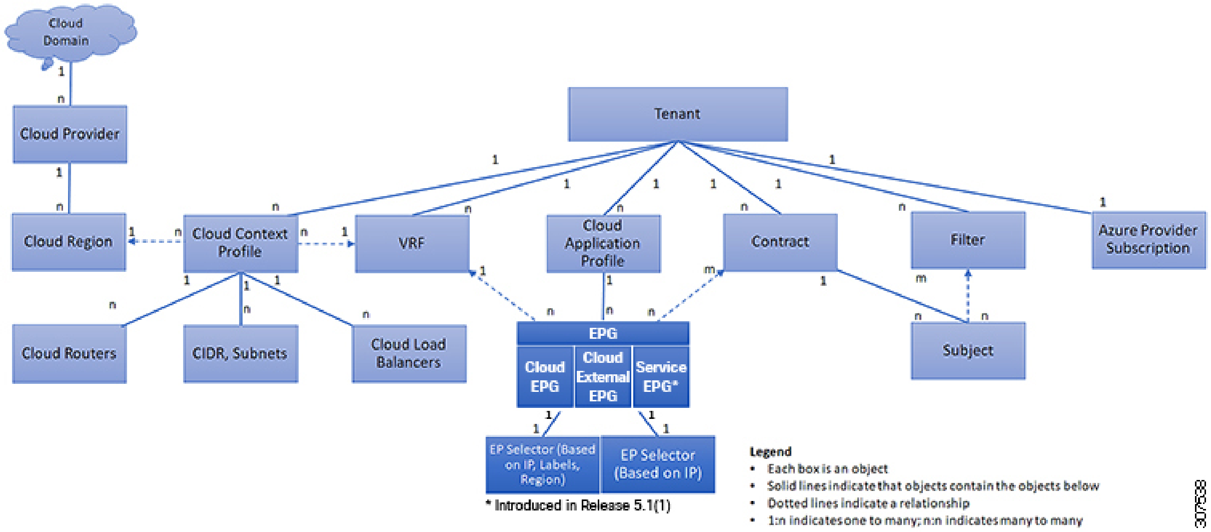
Cloud EPGs can be organized according to one of the following:

- The application they provide, such as a DNS server or SAP application (see *Tenant Policy Example* in *Cisco APIC REST API Configuration Guide*).
- The function they provide (such as infrastructure)
- Where they are in the structure of the data center (such as DMZ)
- Whatever organizing principle that a cloud infrastructure or tenant administrator chooses to use

Cloud Endpoint Groups

The cloud endpoint group (cloud EPG) is the most important object in the policy model. The following figure shows where application cloud EPGs are located in the management information tree (MIT) and their relation to other objects in the tenant.

Figure 6: Cloud Endpoint Groups


Cloud Domain
Cloud Provider
Cloud Region
Cloud Context Profile
VRF
Tenant
Cloud Application Profile
Contract
Filter
Azure Provider Subscription
Cloud Routers
CIDR, Subnets
Cloud Load Balancers
EPG
Cloud EPG
Cloud External EPG
Service EPG*
Subject
EP Selector (Based on IP, Labels, Region)
EP Selector (Based on IP)
* Introduced in Release 5.1(1)
Legend
• Each box is an object
• Solid lines indicate that objects contain the objects below
• Dotted lines indicate a relationship
• 1:n indicates one to many; n:n indicates many to many
307538

A cloud EPG is a managed object that is a named logical entity that contains a collection of endpoints. Endpoints are devices that are connected to the network. They have an address (identity), a location, attributes (such as version or patch level), and are virtual. Knowing the address of an endpoint also enables access to all its other identity details. Cloud EPGs are fully decoupled from the physical and logical topology. Endpoint examples include servers, virtual machines, storage services, or clients on the Internet. Endpoint membership in a cloud EPG can be dynamic or static.

The CCNC cloud infrastructure can contain the following types of cloud EPGs:

- Cloud endpoint group (`cloudEPg`)
- Cloud external endpoint group (`cloudExtEPg`)
- Cloud service endpoint group (`cloudSvcEPg`): Introduced in Release 5.1(2). See Cloud Service Endpoint Groups, on page 20 for more information.

Cloud EPGs contain endpoints that have common policy requirements such as security or Layer 4 to Layer 7 services. Rather than configure and manage endpoints individually, they are placed in a cloud EPG and are managed as a group.

Policies apply to cloud EPGs, never to individual endpoints.

Regardless of how a cloud EPG is configured, cloud EPG policies are applied to the endpoints they contain.

WAN router connectivity to the cloud infrastructure is an example of a configuration that uses a static cloud EPG. To configure WAN router connectivity to the cloud infrastructure, an administrator configures a `cloudExtEPg` cloud EPG that includes any endpoints within an associated WAN subnet. The cloud infrastructure learns of the cloud EPG endpoints through a discovery process as the endpoints progress through their connectivity life cycle. Upon learning of the endpoint, the cloud infrastructure applies the `cloudExtEPg` cloud EPG policies accordingly. For example, when a WAN connected client initiates a TCP session with a server within an application (`cloudEPg`) cloud EPG, the `cloudExtEPg` cloud EPG applies its policies to that client endpoint before the communication with the (`cloudEPg`) cloud EPG web server begins. When the client server TCP session ends, and communication between the client and server terminates, the WAN endpoint no longer exists in the cloud infrastructure.

The Cisco Cloud Network Controller uses endpoint selectors to assign endpoints to Cloud EPGs. The endpoint selector is essentially a set of rules that are run against the cloud instances that are assigned to the Azure VNET managed by Cisco CCNC. Any endpoint selector rules that match endpoint instances assign that endpoint to the Cloud EPG. The endpoint selector is similar to the attribute-based microsegmentation available in Cisco ACI.

Cloud Service Endpoint Groups

A cloud service EPG, introduced in Release 5.1(2), is a managed object that is a named logical entity that contains a collection of cloud native or third-party service instances or endpoints. In this situation, an endpoint refers to a particular service instance. For example, an SQL server would be considered an endpoint, and a collection of SQL servers would form a service endpoint group. Other examples of service EPGs would be a collection of Storage Accounts, a collection of Key Vaults, and so on.

Service EPGs have several unique attributes:

- **Service Type**: This attribute indicates what type of cloud service is being grouped. Examples of available service types include **Azure SQL**, **Azure Containter Registery**, **Azure ApiManagement Services**, and so on. The service type **Custom** is used when configuring a third-party service EPG.
- **Deployment Type**: This attribute indicates how and where the service is deployed. Following are the available deployment types:
    - **Cloud Native**: In this type of deployment, the service is instantiated in the cloud provider's network and the user or applications consuming it have a handle to the service. For example, an Azure storage account might reside inside Azure's own VNet, and you would have a URL to access the storage contents.
    - **Cloud Native Managed**: In this type of deployment, the service is instantiated in your VNet or subnet (created through the Cisco Cloud Network Controller). For example, an Azure Kubernetes cluster (AKS) could be deployed in a subnet that is managed by the Cisco Cloud Network Controller.
    - **Third-Party**: This is a deployment where a third-party (not Azure) is providing services through the market place. Access to this service is provided through the private links feature.
- **Access Type**: This indicates how the service will be accessed. Following are the available access types:
    - **Public**: The service will be accessed using the public IP address assigned to it. Access to the public IP address range of a particular service is achieved using the Azure "Service Tags" in the NSG rules.
    - **Private**: The service will be accessed using a private IP address assigned to it. This assignment is done through the creation of private endpoints when the deployment is of type **Cloud Native** and `Third-Party`. In the case of a **Cloud Native Managed** deployment, the private IP is assigned by the service from the subnet IP space.

Only certain deployment types, and certain access types within each deployment type, are supported for each service type, described in the previous bullets. The following table provides more information on the deployment types and access types that are supported for each service type.

Service Type	Provider	Deployment Type/Access Type		
		Cloud Native	Cloud Native Managed	Third-Party
Azure Storage Blob	Microsoft.Storage	Private	N/A	N/A
Azure SQL	Microsoft.Sql	• Public • Private	N/A	N/A
Azure Cosmos DB	Microsoft.DocumentDB	• Public • Private	N/A	N/A
Azure Databricks	Microsoft.Databricks	Public	• Private • Public and Private	N/A
Azure Storage	Microsoft.Storage	• Public • Private	N/A	N/A
Azure Storage File	Microsoft.Storage	Private	N/A	N/A
Azure Storage Queue	Microsoft.Storage	Private	N/A	N/A
Azure Storage Table	Microsoft.Storage	Private	N/A	N/A
Azure Kubernetes Services (AKS)	Microsoft.ContainerService	Private	• Private • Public and Private	N/A
Azure Active Directory Domain Services	Microsoft.AAD	Public	• Private • Public and Private	N/A
Azure Container Registry	Microsoft.ContainerRegistry	• Public • Private	N/A	N/A
Azure ApiManagement Services	Microsoft.ApiManagement	Public	• Private • Public and Private	N/A
Azure Key Vault	Microsoft.KeyVault	• Public • Private	N/A	N/A
Redis Cache	Microsoft.Cache	N/A	• Private • Public and Private	N/A

Service Type	Provider	Deployment Type/Access Type		
		Cloud Native	Cloud Native Managed	Third-Party
Custom Service		- Public - Private	N/A	Private

- **Service Endpoint Selectors**: Service endpoints can be selected using the existing selectors (used in the cloud EPG selection) as well as the new types of selectors listed below:
  - **Resource Name**: The service resource's name
  - **Resource ID**: The cloud provider's ID for the resource
  - **URL**: The alias or FQDN that identifies the service (the private link alias is used in Azure)

  The following table provides more information on the endpoint selectors that are supported for each deployment type.

Note Information for the Cloud Native (Public) deployment type is not provided in the following table because that deployment type does not support endpoint selectors.

Deployment Type	Tags	Region	IP	Resource Name	Resource ID	URL
Cloud Native (Private)	Y	Y	N	Y	Y	N
Cloud Native Managed	N	N	Y	N	N	N
Third-Party	N	N	N	N	N	Y (applicable only for private link connection)

Guidelines and Restrictions for Cloud Service EPGs

You must have the **NSG-per-subnet** configuration enabled if you are configuring cloud service EPGs. See Security Groups, on page 27 for more information.

About Service Types

Additional information specific to certain service types are provided below:

- Azure Storage, on page 23
- Azure ApiManagement Services, on page 23
- Azure Databricks Services, on page 24
- Azure Active Directory Domain Services, on page 24

- Azure Kubernetes Services, on page 24
- Azure Redis Cache, on page 24

Azure Storage

The Azure Storage service type is a general service type that can be broken down into four subtypes:

- `Blob`
- `File`
- `Table`
- `Queue`

If you were to configure a service EPG with the following values, using the general Azure Storage service type:

- **Service type**: `Azure Storage`
- **Deployment type**: `Cloud Native`
- **Access type**: `Private`

Then four private endpoints are automatically configured for this service EPG, one for each of the four subtypes listed above.

However, if you were to configure a service EPG with the following values, using a more specific Azure Storage service type:

- **Service type**: One of these service types:
  - `Azure Storage Blob`
  - `Azure Storage File`
  - `Azure Storage Table`
  - `Azure Storage Queue`
- **Deployment type**: `Cloud Native`
- **Access type**: `Private`

Then only one private endpoint is automatically configured for this particular subtype for this service EPG.

Note that the four specific Azure Storage subtypes (`Blob`, `File`, `Table`, and `Queue`) are not allowed if you have an access type of `Public` with the deployment type of `Cloud Native`. This is because Azure service tags are not storage subtype specific.

Azure ApiManagement Services

For an Azure ApiManagement (APIM) Services instance to be deployed in a VNet, it needs to be able to access a lot of other Azure services. In order to do this, the security group rules that allow this access must be programmed.

Cisco Cloud Network Controller automates this and configures the rules listed here:

https://docs.microsoft.com/en-us/azure/api-management/api-management-using-with-vnet#-common-network-configuration-issues

Azure Databricks Services

Azure Databricks requires the following:

- Access to other services
- Two subnets for deployment, where the subnets are delegated to Microsoft

For Azure Databricks, make the following configurations:

- Before configuring the service EPG, you must configure two subnets specifically for the Azure Databricks Services.
- When configuring the service EPG, you must create two service endpoint selectors that will be used to match the two service subnets.

Once the subnet is identified with the Azure Databricks service EPG through the configured endpoint selectors, Cisco Cloud Network Controller delegates subnets to Azure and configures the rules listed here:

https://docs.microsoft.com/en-us/azure/databricks/administration-guide/cloud-configurations/azure/vnet-inject

Azure Active Directory Domain Services

Azure Active Directory Domain Services (ADDS) requires the following:

- Access to other services
- No routing table is attached to the subnet when it is being deployed

The action of de-associating the routing table from the subnet should be done through the Azure portal after configuring the service EPG and before deploying ADDS. The routing table can be attached to the subnet after the deployment is completed.

Cisco Cloud Network Controller automates the programming of the rules listed here:

https://docs.microsoft.com/en-us/azure/active-directory-domain-services/network-considerations

Azure Kubernetes Services

Azure Kubernetes Services (AKS) requires access to other services.

Cisco Cloud Network Controller automates the programming of the rules listed here:

https://docs.microsoft.com/en-us/azure/aks/limit-egress-traffic#required-outbound-network-rules-and-fqdns-for-aks-clusters

See Service EPG Configuration Examples for an example configuration of the AKS service EPG.

Azure Redis Cache

Azure Redis cache requires access to other services.

Cisco Cloud Network Controller automates the programming of the rules listed here:

https://docs.microsoft.com/en-us/azure/azure-cache-for-redis/cache-how-to-premium-vnet#outbound-port-requirements

About Deployment Types

Additional information specific to certain deployment types are provided below:

- Cloud Native, on page 25
- Cloud Native Managed, on page 26

Cloud Native

In this type of deployment, the service is instantiated in the cloud provider's network and the user or applications consuming it have a handle to the service. For example, an Azure storage account might reside inside Azure's own VNet, and you would have a URL to access the storage contents.

The following is an example service EPG with a Cloud Native deployment type:

- **Service Type**: Azure SQL
- **Deployment type**: Cloud Native
- **Access type**: Private

In this example scenario, you would make the following configurations in this order:

1. In the Cisco Cloud Network Controller GUI, create a private link label in a cloud context profile to be used by the Azure SQL service EPG.

   Follow the procedures in Creating a Cloud Context Profile Using the Cisco Cloud Network Controller GUI. Configure a private link label to be used by the Azure SQL service EPG (for example, `SQL-PLL`).

2. In the Cisco Cloud Network Controller GUI, create a service EPG of the service type Azure SQL.

   Follow the procedures in Creating a Service EPG Using the Cisco Cloud Network Controller GUI, using the following parameters:

   - **Service Type**: Azure SQL
   - **Deployment type**: Cloud Native
   - **Access type**: Private

   When you are configuring the endpoint selector as part of the process of configuring this type of service EPG, configure the endpoint selector to match the appropriate value for the SQL server.

   For example, if you wanted to select an SQL server with the name `ProdSqlServer`, you would make the following selections:

   - **Key**: Name
   - **Operator**: equals
   - **Value**: `ProdSqlServer`

   As another example, if you wanted to select an SQL server using the cloud provider's resource ID of `/subscriptions/{subscription-id}/resourceGroups/{resourceGroupName}/providers/Microsoft.Sql/servers/ProdSqlServer`, you would make the following selections:

   - **Key**: Resource ID
   - **Operator**: equals

- **Value**: `/subscriptions/{subscription-id}/resourceGroups/{resourceGroupName}/providers/Microsoft.Sql/servers/ProdSqlServer`

3. In the Azure portal, configure the Azure SQL resources in the cloud.

Cloud Native Managed

In this type of deployment, the service is instantiated in your VNet or subnet (created through the Cisco Cloud Network Controller). For example, an Azure ApiManagement Services could be deployed in a subnet that is managed by the Cisco Cloud Network Controller.

The following is an example service EPG with a Cloud Native Managed deployment type:

- **Service Type**: Azure ApiManagement Services
- **Deployment type**: Cloud Native Managed
- **Access type**: Private

In this example scenario, you would make the following configurations in this order:

1. In the Cisco Cloud Network Controller GUI, create a subnet in a cloud context profile to be used by the Azure ApiManagement Services service EPG.

   Follow the procedures in Creating a Cloud Context Profile Using the Cisco Cloud Network Controller GUI. Configure a subnet to be used by the Azure ApiManagement Services service EPG (for example, `10.50.0.0/16`).

2. In the Cisco Cloud Network Controller GUI, create a service EPG of the service type Azure ApiManagement Services.

   Follow the procedures in Creating a Service EPG Using the Cisco Cloud Network Controller GUI, using the following parameters:

   - **Service Type**: Azure ApiManagement Services
   - **Deployment type**: Cloud Native Managed
   - **Access type**: Private

   When you are configuring the endpoint selector as part of the process of configuring this type of service EPG, configure the endpoint selector to match the IP address that you used when you created a subnet in the cloud context profile in the first step.

   For example, using the example provided in the first step, you would configure this endpoint selector for this service EPG:

   - **Key**: IP
   - **Operator**: equals
   - **Value**: 10.50.0.0/16

3. In the Azure portal, configure the Azure ApiManagement Services resources in the cloud.

Security Groups

In Azure, two types of security groups are used to administer and control network traffic within a virtual network (VNet):

- **Network security groups**: Network security groups, or NSGs, are used in Azure to filter network traffic to and from Azure resources. An NSG is used to define incoming and outgoing security policies, and contains security rules that allow or deny inbound network traffic to, or outbound network traffic from, several types of Azure resources. For each rule, you can specify source and destination, port, and protocol.

  In Cisco Cloud Network Controller, an NSG is automatically configured based on a contract.

- **Application security groups**: Application security groups, or ASGs, are used in Azure to group virtual machine (VM) NICs according to the applications that run on them and define network security policies based on those groups. ASGs are used within an NSG to define these security polices and to apply a network security rule to a specific workload or group of virtual machines.

  In Cisco Cloud Network Controller, an ASG is a collection of endpoints for each EPG and is referenced as the source or destination in the NSG security policies.

The way that these security groups are configured, and what they are mapped to, differ depending on the release.

- Releases Prior to Release 5.1(2): NSG-Per-EPG Configurations, on page 27
- Release 5.1(2) and Later: NSG-Per-Subnet Configurations, on page 27
- Release 5.1(2g) and Later: IP-Based Rules for Inter-VRF Contracts in the Same VNet, on page 28

Releases Prior to Release 5.1(2): NSG-Per-EPG Configurations

For releases prior to Release 5.1(2), there is a one-to-one mapping between NSGs in Azure and EPGs on Cisco Cloud Network Controller (these configurations are also referred to as **NSG-per-EPG** configurations throughout this document). These NSGs for the Cisco Cloud Network Controller EPGs are populated with security rules based on contracts associated with the EPGs.

For releases prior to Release 5.1(2), the creation of an EPG in Cisco Cloud Network Controller results in the creation of the following Azure components:

- An ASG, which is used to group all endpoints or virtual machine NICs for each EPG based on the endpoint selectors
- An NSG, which gets associated with all of the NICs in that ASG and provides the security policy definition for that EPG

Release 5.1(2) and Later: NSG-Per-Subnet Configurations

Beginning with Release 5.1(2), in addition to the existing NSG-per-EPG configurations available previously, NSGs in Azure can also have a one-to-one mapping with subnets rather than EPGs on Cisco Cloud Network Controller (these configurations are also referred to as **NSG-per-subnet** configurations throughout this document). By default, NSGs are no longer created for EPGs beginning with Release 5.1(2), and NSGs are no longer associated with the endpoints and VM NICs in the ASG for that EPG. Instead, the NSG for each subnet will contain all of the rules based on the contracts for the ASGs, which have their endpoints discovered in the subnet.

For NSG-per-subnet configurations, the creation of an EPG in Cisco Cloud Network Controller results in the creation of the following Azure components:

- An ASG, which is used to group all endpoints or virtual machine NICs for each EPG based on the endpoint selectors [essentially no change in behavior for ASGs from releases prior to Release 5.1(2)]
- An NSG, which continues to provide the security policy definition for that EPG, but now gets associated with a subnet in a Cisco Cloud Network Controller -managed VNet

Looked at from another perspective:

- Every EPG in a Cisco Cloud Network Controller -managed VNet will have an ASG associated with it, which will group all the endpoints based on the endpoint selectors configured for the EPG.
- Every subnet in a Cisco Cloud Network Controller -managed VNet will have an NSG associated with it.

The default setting for a Greenfield or a fresh Cisco Cloud Network Controller deployment is **NSG-per-subnet**. When manually setting this configuration, as described previously, you can choose either a newer **NSG-per-subnet** configuration or the older **NSG-per-EPG** configuration beginning with Release 5.1(2). However, we recommend choosing the newer **NSG-per-subnet** configuration for several reasons:

- Using the **NSG-per-subnet** configuration reduces the number of NSGs in the VNet, and also reduces the number of rules for deployments with a large number of subnets accessing common shared services. This provides for easier management, since all of the rules can be checked in one NSG for a subnet, rather than for each NSG mapped to individual EPGs or ASGs.
- You must use the **NSG-per-subnet** configuration if you are configuring service EPGs. See Cloud Service Endpoint Groups, on page 20 for more information.

See Configuring Network Security Groups Using the Cisco Cloud Network Controller GUI for instructions on enabling or disabling the NSG-per-EPG or NSG-per-subnet configurations.

Release 5.1(2g) and Later: IP-Based Rules for Inter-VRF Contracts in the Same VNet

Prior to release 5.1(2g), if two EPGs had a contract and were in the same VNet but belonged to different VRFs, ASG-based rules were used to enable communication between those hosted VRFs in that VNet. Azure has a limit of 100 ASGs in rules for every NSG, and this limit could be reached quickly in some situations (for example, if you have one VNet for all of your shared services).

Beginning with release 5.1(2g), if two EPGs have a contract and are in the same VNet but belong to different VRFs, IP-based rules are now used to enable communication between those hosted VRFs in that VNet, which is preferrable because an NSG can support 4000 IP addresses in the rules. These IP-based rules are based on endpoints discovered or on subnet selectors used in the EPG.

Guidelines and Limitations for ASGs and NSGs

Following are the guidelines and limitations for ASGs and NSGs.

- Guidelines and Limitations for Releases Prior to 5.1(2), on page 29
- Guidelines and Limitations for Release 5.1(2) or Later, on page 29

Guidelines and Limitations for Releases Prior to 5.1(2)

For releases prior to Release 5.1(2), support is only available for NSG-to-EPG mapping for Cisco Cloud Network Controller.

Guidelines and Limitations for Release 5.1(2) or Later

- Beginning with Release 5.1(2), support is also available for NSG-to-subnet mapping for Cisco Cloud Network Controller. However, you can have *either* the newer NSG-per-subnet configuration or the NSG-per-EPG configuration, but not both in the same Cisco Cloud Network Controller system.
- You can configure one NSG per subnet in a Cisco Cloud Network Controller -managed VNET. Having one NSG per a group of subnets is not supported for Cisco Cloud Network Controller at this time.
- Passthrough devices, such as transparent firewall, will not have NSGs attached to their NICs. If there are multiple passthrough devices sharing a subnet, the passthrough rules for each device will apply to all endpoints in the subnet.

Security Rules

The security rules for NSG differ, depending on whether they are rules for NSG-per-EPG configurations or for NSG-per-subnet configurations. A major distinction on the processing of the security rules between the two types of configurations is the trigger for installing and deleting the rules.

- NSG-Per-EPG Security Rules, on page 29
- NSG-Per-Subnet Security Rules, on page 29

NSG-Per-EPG Security Rules

- Once the EPGs and the contract are defined on the Cisco Cloud Network Controller, the NSG security rules that use ASGs as the source and destination are always programmed, regardless of whether an endpoint for the ASG that is referenced in the NSG security rule is discovered or not.
- For inter-VRF contracts:
  - If either the consumer or the provider EPG uses an endpoint selector based on subnet, then the NSG security rules that have the source or destination as the subnet from the EPG selector are always programmed, regardless of the discovery of an endpoint.
  - If the consumer or provider EPG does not use an endpoint selector based on subnet, then the NSG security rules using the endpoint's IP address as the source and destination are programmed, depending on the discovery of an endpoint.
- The rules created for an inter-site contract, where a cloud external EPG (`cloudExtEPg`) is involved, also get pre-programmed without the endpoint getting discovered.

NSG-Per-Subnet Security Rules

The NSG security rules for an EPG are not programmed in a subnet-based NSG until the EPG has at least one endpoint discovered in that subnet.

NSG Behavior With Software Upgrades or Downgrades

Because only NSG-per-EPG mapping is supported for releases prior to Release 5.1(2), and support for NSG-per-subnet mapping became available beginning with Release 5.1(2), certain system configuration changes might have to take place when you are upgrading or downgrading your software in certain situations. The following sections describe these situations and what must occur during these upgrade or downgrade operations.

- NSG Behavior With Software Upgrades, on page 30
- NSG Behavior With Software Downgrades, on page 30

NSG Behavior With Software Upgrades

When you perform a standard upgrade from a release prior to Release 5.1(2) to Release 5.1(2) or later, NSGs that were configured using the NSG-per-EPG mapping that was supported for the release prior to Release 5.1(2) will remain as-is after the upgrade. This is because either NSG-per-EPG or NSG-per-subnet configurations are supported for Release 5.1(2) or later, so the older NSG-per-EPG configurations will be retained automatically when performing a standard upgrade to Release 5.1(2) or later.

However, there are benefits to the NSG-per-subnet configuration, so we recommend that you convert the NSG-per-EPG configurations to NSG-per-subnet to take advantage of those benefits. See Security Groups, on page 27 for more information on the different NSG configurations, and Configuring Network Security Groups Using the Cisco Cloud Network Controller GUI for instructions on enabling or disabling the NSG-per-EPG or NSG-per-subnet configurations.

Keep in mind that, after the upgrade, you can have either older NSG-per-EPG or the newer NSG-per-subnet configuration, but you cannot have both in the same Cisco Cloud Network Controller system. See Guidelines and Limitations for ASGs and NSGs, on page 28 for more information.

However, if you backed up your existing Cisco Cloud Network Controller configuration using the procedures in Creating a Backup Configuration Using the Cisco Cloud Network Controller GUI, then performed an upgrade and imported the backed-up configuration after the upgrade, the NSG-per-subnet configuration is turned on automatically, and any older NSG-per-EPG configurations are automatically converted to the newer NSG-per-subnet configuration.

NSG Behavior With Software Downgrades

When you downgrade from Release 5.1(2) or later to a release prior to Release 5.1(2), you must manually move any NSG-per-subnet configurations back to the NSG-per-EPG configuration that was supported for releases prior to Release 5.1(2).

Following is the general process that you will follow to transition from NSG-per-subnet configurations to NSG-per-EPG configurations before downgrading the software:

1. Before downgrading the software from Release 5.1(2) or later to a release prior to Release 5.1(2), disable the NSG-per-subnet configuration using the procedures provided in Configuring Network Security Groups Using the Cisco Cloud Network Controller GUI. The Cisco Cloud Network Controller software begins the transition from NSG-per-subnet mapping to NSG-per-EPG mapping.
2. Wait until the transition is complete, where the Cisco Cloud Network Controller software has deleted all of the NSGs that were configured as part of the NSG-per-subnet mapping process and has created new NSGs for the NSG-per-EPG mapping configuration. If you attempt to proceed with the downgrade before the transition is complete, you will see an error message and the Cisco Cloud Network Controller software

will not allow you to proceed with the downgrade until this transition from NSG-per-subnet mapping to NSG-per-EPG mapping has completed.

Note You will get an error message if you attempt a software downgrade before the transition is complete when downgrading through the GUI; however, you will not get an error message if you attempt a software downgrade too early when downgrading through the REST API. For that reason, we recommend that you do not downgrade your software through the REST API if you are in this situation.

If you decide to downgrade your software through the REST API, monitor the following MO:

```
hcloudReconcileDone
```

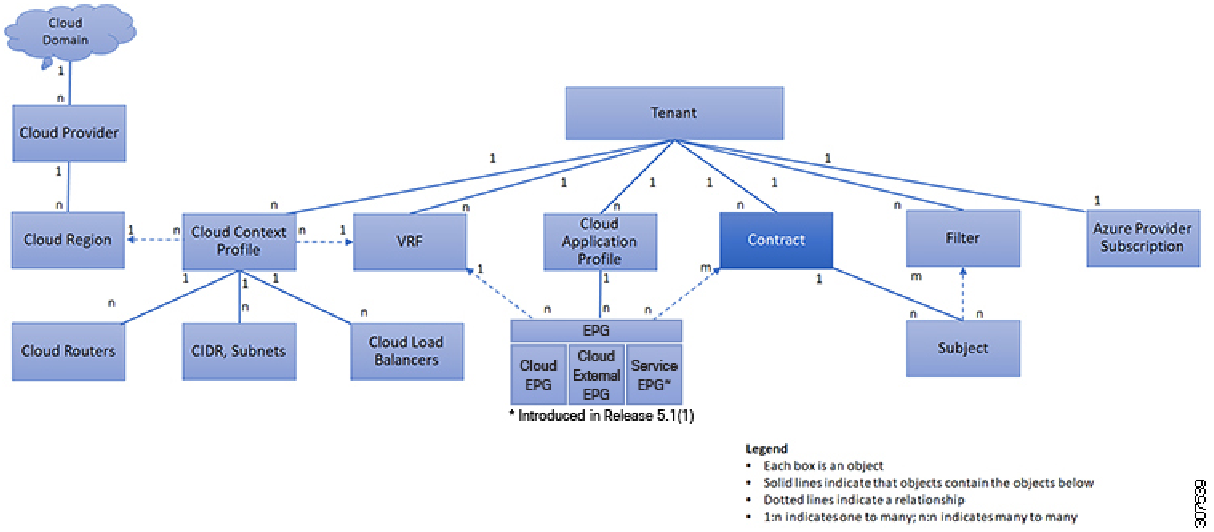
Verify that the property `sgForSubnetModeConverged` is set to `yes` before proceeding with the downgrade through the REST API.

3. When you have confirmation that the system has successfully completed the transition back to the NSG-per-EPG mapping, you can downgrade the Cisco Cloud Network Controller software using the instructions provided in the *Cisco Cloud Network Controller for Azure Installation Guide*.

Contracts

In addition to cloud EPGs, contracts (`vzBrCP`) are key objects in the policy model. Cloud EPGs can only communicate with other cloud EPGs according to contract rules. The following figure shows the location of contracts in the management information tree (MIT) and their relation to other objects in the tenant.

Figure 7: Contracts


Cloud Domain
Cloud Provider
Cloud Region
Cloud Context Profile
Cloud Routers
CIDR, Subnets
Cloud Load Balancers
Tenant
VRF
Cloud Application Profile
Contract
Filter
Azure Provider Subscription
EPG
Cloud EPG
Cloud External EPG
Service EPG*
Subject
* Introduced in Release 5.1(1)
Legend
• Each box is an object
• Solid lines indicate that objects contain the objects below
• Dotted lines indicate a relationship
• 1:n indicates one to many; n:n indicates many to many
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An administrator uses a contract to select one or more types of traffic that can pass between cloud EPGs, including the protocols and ports allowed. If there is no contract, inter-EPG communication is disabled by default. There is no contract required for intra-EPG communication; intra-EPG communication is always implicitly allowed.

Contracts govern the following types of cloud EPG communications:

- Between cloud EPGs (`cloudEPg`), both intra-tenant and inter-tenant

  Note In the case of a shared service mode, a contract is required for inter-tenant communication. A contract is used to specify static routes across VRFs, although the tenant VRF does not enforce a policy.

- Between cloud EPGs and cloud external EPGs (`cloudExtEPg`)

Contracts govern the communication between cloud EPGs that are labeled providers, consumers, or both. The relationship between a cloud EPG and a contract can be either a provider or consumer. When a cloud EPG provides a contract, communication with the cloud endpoints in that cloud EPG can be initiated from cloud endpoints in other cloud EPGs as long as the communication complies with the provided contract. When a cloud EPG consumes a contract, the cloud endpoints in the consuming cloud EPG may initiate communication with any cloud endpoint in a cloud EPG that is providing that contract.

Note A cloud EPG can both provide and consume the same contract. A cloud EPG can also provide and consume multiple contracts simultaneously.

Comma-separated Filters Support for Contract Rule Consolidation

After a contract is created, some of the rules defined in the contract are consolidated and displayed in Azure based on certain criteria. You can combine multiple ports and multiple IP addresses and ranges into a single, easy-to-understand rule. The criteria for consolidation of rules are:

- Rules are consolidated only within a contract. Two rules resulting from two different contracts are not consolidated in Azure.
- The source/ destination address prefixes and destination port(s) are consolidated.
- The conditions for multiple rules to get consolidated together in an NSG are:
  - Same contract
  - Same protocol (UDP, TCP,ICMP)
  - Same direction (inbound, outbound)
  - Same type (SG, IP)
- Overlapping port ranges for same protocol (TCP/UDP) in the same contract are consolidated to one range.

  For example, TCP ports 100-200, 150-250 are consolidated to 100-250.
- If 1.2.3.4/32 (any address prefixes) is allowed, and an ext EPG with 0.0.0.0/0 is added, then the allowed Source/Destination IP would be *Any*, not [1.2.3.4/32, 0.0.0.0/0].

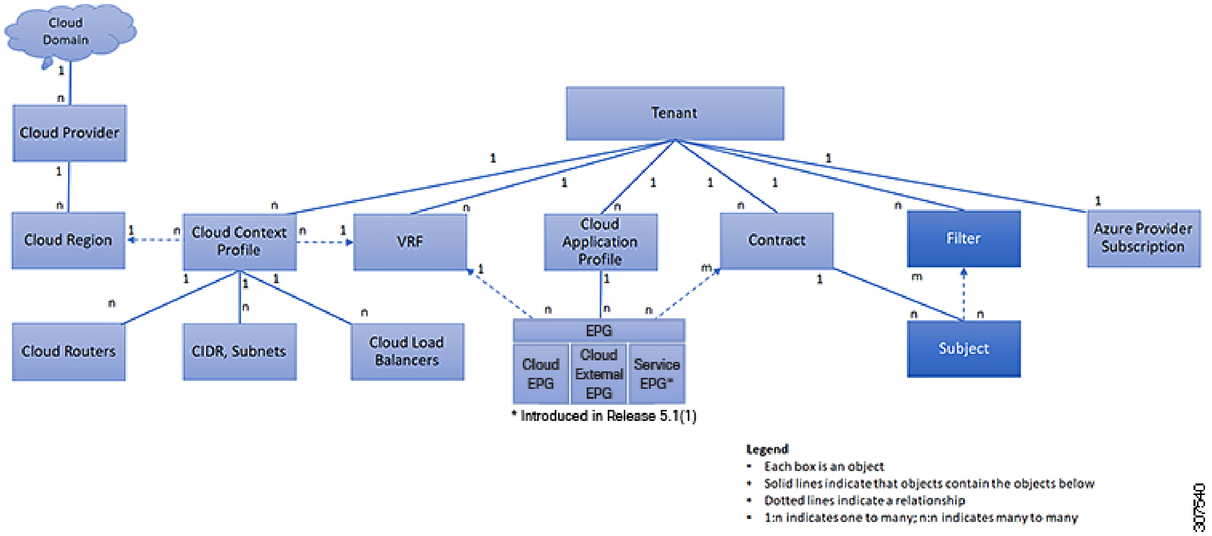
The example below shows the EPG1 outbound rules and the consolidated EPG1 outbound rules, based on contracts C1 and C2.

```
Contract C1:
Consumer: EPG1, Provider: EPG2
Filter: TCP  (ports 53)
Filter: UDP (port 53, 5000)

Contract C2:
Consumer: EPG1, Provider: EPG2
Filter: TCP (ports 80, 8080)

EPG1 outbound rules:
EPG1 -> EPG2   TCP  80
EPG1 -> EPG2   TCP  8080
EPG1 -> EPG2        TCP        53
EPG1 -> EPG2   UDP  53
EPG1 -> EPG2   UDP  5000
EPG1 -> 1.1.1.1/32  TCP  80
EPG1 -> 1.1.1.1/32  TCP  8080
EPG1 -> 1.1.1.1/32  TCP  53
EPG1 -> 1.1.1.1/32  UDP  53
EPG1 -> 1.1.1.1/32  UDP 5000
EPG1 -> 2.2.2.2/32  TCP  80
EPG1 -> 2.2.2.2/32  TCP  8080
EPG1 -> 2.2.2.2/32  TCP       53
EPG1 -> 2.2.2.2/32  UDP  53
EPG1 -> 2.2.2.2/32  UDP  5000

Rules are consolidated by comma-separated filters (consolidated based on C1 and C2):
EPG1 -> EPG2     TCP  80,8080
EPG1 -> EPG2     UDP  53,5000
EPG1 -> EPG2     TCP  53
EPG1 -> 1.1.1.1/32, 2.2.2.2/32   TCP  80,8080
EPG1 -> 1.1.1.1/32, 2.2.2.2/32   UDP  53,5000
EPG1 -> 1.1.1.1/32, 2.2.2.2/32   TCP  53
```

Filters and Subjects Govern Cloud EPG Communications

Subject and filter managed-objects enable mixing and matching among cloud EPGs and contracts so as to satisfy various applications or service delivery requirements. The following figure shows the location of application subjects and filters in the management information tree (MIT) and their relation to other objects in the tenant.

Figure 8: Subjects and Filters


Cloud Domain
Cloud Provider
Cloud Region
Cloud Context Profile
VRF
Cloud Application Profile
Contract
Filter
Azure Provider Subscription
Tenant
Cloud Routers
CIDR, Subnets
Cloud Load Balancers
EPG
Cloud EPG
Cloud External EPG
Service EPG*
Subject
1
n
m
* Introduced in Release 5.1(1)
Legend
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• Dotted lines indicate a relationship
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Contracts can contain multiple communication rules and multiple cloud EPGs can both consume and provide multiple contracts. A policy designer can compactly represent complex communication policies and re-use these policies across multiple instances of an application.

Note Subjects are hidden in Cisco Cloud Network Controller and not configurable. For rules installed in Azure, source port provided in the filter entry is not taken into account.

Subjects and filters define cloud EPG communications according to the following options:

- Filters are Layer 3 to Layer 4 fields, TCP/IP header fields such as Layer 3 protocol type, Layer 4 ports, and so forth. According to its related contract, a cloud EPG provider dictates the protocols and ports in both the in and out directions. Contract subjects contain associations to the filters (and their directions) that are applied between cloud EPGs that produce and consume the contract.
- Subjects are contained in contracts. A subject within a contract uses filters to specify the type of traffic that can be communicated and how it occurs. For example, for HTTPS messages, the subject specifies the direction and the filters that specify the IP address type (for example, IPv4), the HTTP protocol, and the ports allowed. Subjects determine if filters are unidirectional or bidirectional. A unidirectional filter is used in one direction. Unidirectional filters define in or out communications but not the same for both. Bidirectional filters are the same for both; they define both in and out communications.
- CCNC contracts rendered in Azure constructs are always stateful, allowing return traffic.

About the Cloud Template

The cloud template provides a template that configures and manages the Cisco Cloud Network Controller infra network. The template requires only the most essential elements for the configuration. From these elements, the cloud template generates a detailed configuration necessary for setting up the Cisco Cloud Network Controller infra network. However, it is not a one-time configuration generation—it is possible to add, modify, or remove elements of the template input. The cloud template updates the resulting configuration accordingly.

One of the central things in the Azure network configuration is the Virtual Private Cloud (VNET). Azure supports many regions worldwide and one VNET is specific to one region.

The cloud template accepts one or more region names and generates the entire configuration for the infra VNETs in those regions. They are the infra VNETs. The Cisco Cloud Network Controller -managed object (MO) corresponding to the Azure VNET is `cloudCtxProfile`. For every region specified in the cloud template, it generates the `cloudCtxProfile` configuration. A `cloudCtxProfile` is the topmost MO for all the configuration corresponding to a region. Underneath, it has many of other MOs organized as a tree to capture a specific configuration. The `cloudCtxProfile` MO for the infra VNet is generated by the cloud template. It carries `ctxProfileOwner == SYSTEM`, which means that this MO is generated by the system. For the non-infra network, it is possible to configure `cloudCtxProfile` directly; in this case, `cloudCtxProfile` carries `ctxProfileOwner == USER`.

A primary property of an Azure VNet is the CIDR. In Cisco Cloud Network Controller, you can choose and deploy CIDRs in the user VNets. The CIDRs for the infra VNet are provided by users to the cloud template during the initial setup of the cloud site, and are deployed to the Azure cloud by the cloud template.

Beginning with release 5.0(2), a new property called `createdBy` is added for the CIDR. The default value for this `createdBy` property is `USER`.

- For all user-created CIDRs, the value for the `createdBy` property is set to `USER`.
- For cloud template-created CIDRs, the value for the `createdBy` property is set to `SYSTEM`.

Multiple CIDR and subnet blocks can be configured on the infra VNet. You can create CIDRs and associate subnets in the infra VNet. The cloud template subnets will be mapped to the overlay-1 VRF, but for user-created subnets, you have to manually configure the subnet-to-VRF mapping to the secondary VRF in the same infra VNet. All subnets in the respective VRFs will have separate route tables in the cloud for VRF segregation.

You can create cloud EPGs and cloud external EPGs in the infra tenant, where all the cloud EPGs and cloud external EPGs will be associated with the secondary VRF in the infra tenant. A cloud EPG in the secondary VRF can communicate with other cloud EPGs and cloud external EPGs in the secondary VRF, and can also communicate with cloud EPGS in other user tenant VRFs. We recommend that you do not use existing "cloud-infra" application profiles, and instead create a new application profile in the infra tenant and associate that new application profile to the cloud EPGs and cloud external EPGs in the secondary VRF.

For more information, see Creating an Application EPG Using the Cisco Cloud Network Controller GUI.

The cloud template generates and manages a huge number of MOs in the `cloudCtxProfile` subtree including, but not limited to, the following:

- Subnets
- Cloud routers
- IP address allocation for the cloud router interfaces
- IP address allocation and configuration for tunnels
- IP address allocation and configuration for loopbacks

Without the cloud template, you would be responsible for configuring and managing these.

The *Cisco Cloud Template MO* table contains a brief summary of the inputs (MOs) to the cloud template.

Table 1: Cloud Template MOs

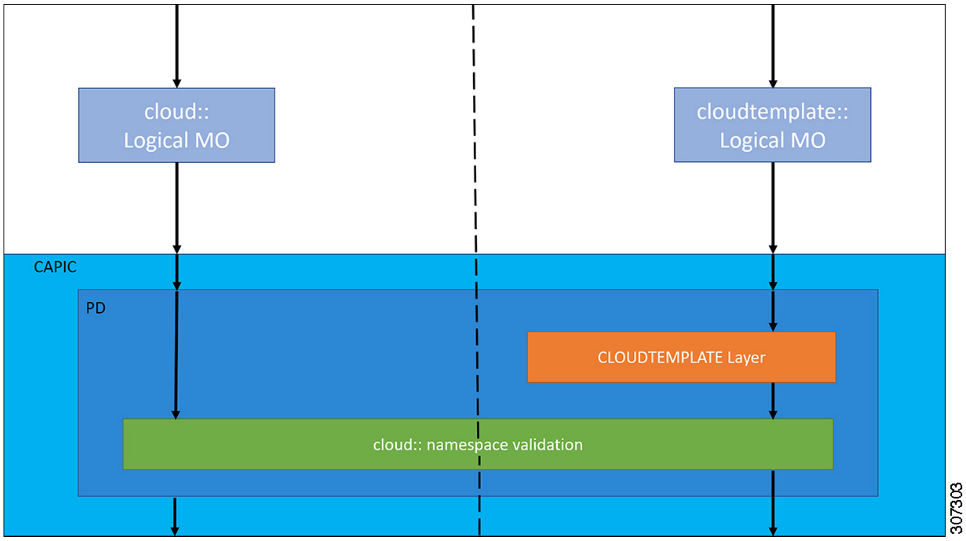
MO	Purpose
`cloudtemplateInfraNetwork`	The root of the cloud template configuration. Attributes include: `numRoutersPerRegion`—The number of cloud routers for each `cloudRegionName` specified under `cloudtemplateIntNetwork`.
`cloudtemplateProfile`	Configuration profile for all the cloud routers. Attributes include: • `routerUsername` **Note** • The username cannot be "admin." • Any username restrictions from Azure applies. • `routerPassword` • `routerThroughput` • `routerLicenseToken` • `routeDataInterfacePublicIP` • `routerMgmtInterfacePublicIP`
`cloudtemplateIntNetwork`	Contains a list of regions, which specify where you deploy the cloud routers. Each region is captured through a `cloudRegionName` child MO
`cloudtemplateExtNetwork`	Contains infra network configuration input that is external of the cloud. Contains a list of regions where cloud routers are configured for external networking. Each region is captured through a `cloudRegionName` child MO
`cloudtemplateVpnNetwork`	Contains information for setting up a VPN with an ACI on-premises site or another Cisco Cloud Network Controller site.
`cloudtemplateIpSecTunnel`	Captures the IP address of the IPSec peer in the ACI on-premises site.
`cloudtemplateOspf`	Captures the OSPF area to be used for the VPN connections.
`cloudtemplateBgpEvpn`	Captures the peer IP address, ASN, and so forth, for setting up the BGP session with the on-premises site.

In Cisco Cloud Network Controller, the layering of MOs is slightly different from a regular Cisco APIC due to the cloud template. In a regular Cisco APIC, you post logical MOs that go through two layers of translation:

1. Logical MO to resolved MO
2. Resolved MO to concrete MO

In Cisco Cloud Network Controller, there is an additional layer of translation for the infra network. This additional layer is where the cloud template translates logical MOs in the `cloudtemplate` namespace to logical MOs in the cloud namespace. For configurations outside of the infra network, you post logical MOs in the cloud namespace. In this case, the MOs go through the usual two-layer translation as in the regular Cisco APIC.

Figure 9: Cloud and Cloud Template MO Conversion



Note For information about configuring the cloud template, see Configuring Cisco Cloud Network Controller Components

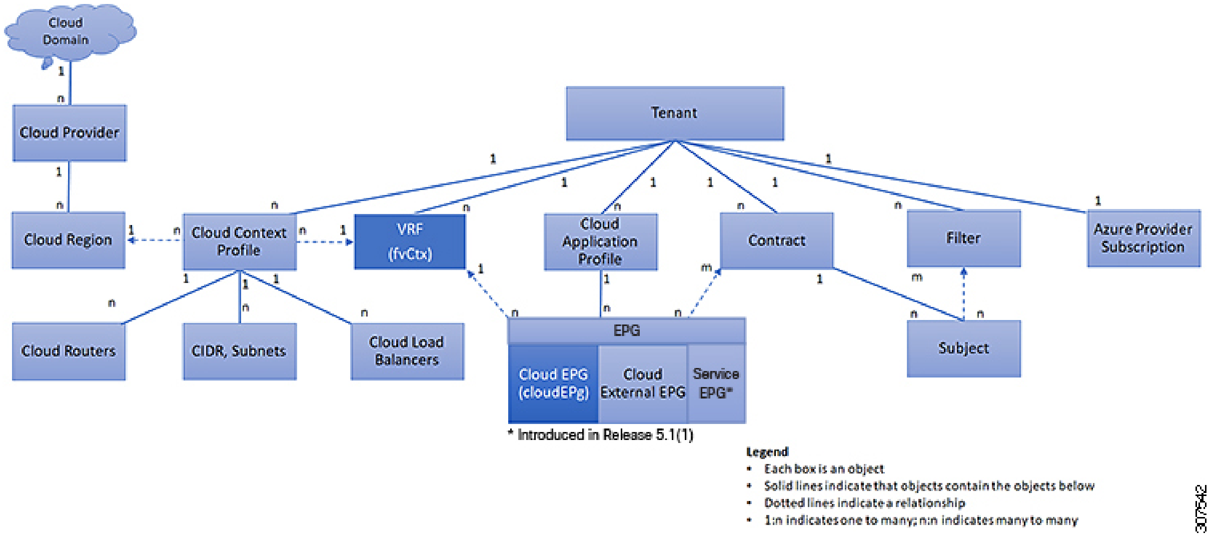
Managed Object Relations and Policy Resolution

Relationship-managed objects express the relation between managed object instances that do not share containment (parent-child) relations. MO relations are established between the source MO and a target MO in one of the following two ways:

- An explicit relation, such as with `cloudRsCloudEPgCtx`, defines a relationship that is based on the target MO distinguished name (DN).
- A named relation defines a relationship that is based on the target MO name.

The dotted lines in the following figure show several common MO relations.

Figure 10: MO Relations


Cloud Domain
Cloud Provider
Cloud Region
Cloud Context Profile
VRF (fvCtx)
Tenant
Cloud Application Profile
Contract
Filter
Azure Provider Subscription
Cloud Routers
CIDR, Subnets
Cloud Load Balancers
EPG
Cloud EPG (cloudEPg)
Cloud External EPG
Service EPG*
Subject
* Introduced in Release 5.1(1)
Legend
Each box is an object
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For example, the dotted line between the cloud EPG and the VRF defines the relation between those two MOs. In this figure, the cloud EPG (`cloudEPg`) contains a relationship MO (`cloudRsCloudEPgCtx`) that is named with the name of the target VRF MO (`fvCtx`). For example, if production is the VRF name (`fvCtx.name=production`), then the relation name is production (`cloudRsCloudEPgCtx.tnFvCtxName=production`).

In the case of policy resolution based on named relations, if a target MO with a matching name is not found in the current tenant, the CCNC cloud infrastructure tries to resolve in the common tenant. For example, if the user tenant cloud EPG contained a relationship MO targeted to a VRF that did not exist in the tenant, the system tries to resolve the relationship in the common tenant. If a named relation cannot be resolved in either the current tenant or the common tenant, the CCNC cloud infrastructure attempts to resolve to a default policy. If a default policy exists in the current tenant, it is used. If it does not exist, the CCNC cloud infrastructure looks for a default policy in the common tenant. Cloud context profile, VRF, and contract (security policy) named relations do not resolve to a default.

Default Policies

Warning Default policies can be modified or deleted. Deleting a default policy can result in a policy resolution process to complete abnormally.

The CCNC cloud infrastructure includes default policies for many of its core functions. Examples of default policies include the following:

- Cloud Azure provider (for the infra tenant)
- Monitoring and statistics

Note To avoid confusion when implementing configurations that use default policies, document changes made to default policies. Be sure that there are no current or future configurations that rely on a default policy before deleting a default policy. For example, deleting a default firmware update policy could result in a problematic future firmware update.

A default policy serves multiple purposes:

- Allows a cloud infrastructure administrator to override the default values in the model.
- If an administrator does not provide an explicit policy, the Cisco Cloud Network Controller applies the default policy. An administrator can create a default policy and the Cisco Cloud Network Controller uses that unless the administrator provides any explicit policy.

The following scenarios describe common policy resolution behavior:

- A configuration explicitly refers to the default policy: if a default policy exists in the current tenant, it is used. Otherwise, the default policy in tenant **common** is used.
- A configuration refers to a named policy (not default) that does not exist in the current tenant or in tenant common: if the current tenant has a default policy, it is used. Otherwise, the default policy in tenant **common** is used.

  Note The scenario above does not apply to a VRF in a tenant.

- A configuration does not refer to any policy name: if a default policy exists in the current tenant, it is used. Otherwise, the default policy in tenant **common** is used.

The policy model specifies that an object is using another policy by having a relation-managed object (MO) under that object and that relation MO refers to the target policy by name. If this relation does not explicitly refer to a policy by name, then the system tries to resolve a policy that is called default. Cloud context profiles and VRFs are exceptions to this rule.

Shared Services

Cloud EPGs in one tenant can communicate with cloud EPGs in another tenant through a contract interface that is contained in a shared tenant. Within the same tenant, a cloud EPG in one VRF can communicate with another cloud EPG in another VRF through a contract defined in the tenant. The contract interface is an MO that can be used as a contract consumption interface by the cloud EPGs that are contained in different tenants. By associating to an interface, a cloud EPG consumes the subjects that are represented by the interface to a contract contained in the shared tenant. Tenants can participate in a single contract, which is defined at some third place. More strict security requirements can be satisfied by defining the tenants, contract, subjects, and filter directions so that tenants remain isolated from one another.

Follow these guidelines when configuring shared services contracts:

- A shared service is supported only with non-overlapping and non-duplicate CIDR subnets. When configuring CIDR subnets for shared services, follow these guidelines:
  - CIDR subnets leaked from one VRF to another must be disjointed and must not overlap.

- CIDR subnets advertised from multiple consumer networks into a VRF or vice versa must be disjointed and must not overlap.
- Inter-tenant contracts require a global scope.