



## **Cisco APIC Security Configuration Guide, Release 5.0(x)**

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# CHAPTER 1

## New and Changed Information

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This chapter contains the following sections:

- [New and Changed Information, on page 1](#)

## New and Changed Information

The following table provides an overview of the significant changes to the organization and features in this guide up to this current release. The table does not provide an exhaustive list of all changes made to the guide or of the new features up to this release.

**Table 1: New Features and Changed Behavior for Cisco APIC Release 5.0(x)**

Feature or Change	Description	Where Documented
Endpoint Security Groups	Endpoint Security Groups (ESGs) are the new network security component in Cisco ACI infrastructure.	<a href="#">Endpoint Security Groups, on page 147</a>
DUO two factor authentication	The two factor authentication with DUO proxy in Cisco APIC.	<a href="#">DUO Two Factor Authentication, on page 65</a>
Per-Leaf RBAC	The ability to assign a physical leaf to a security domain for configuration and management.	<a href="#">Assigning a Node to a Domain, on page 46</a>

Feature or Change	Description	Where Documented
Consolidated Privileges	<p>The number of privileges is reduced from earlier releases, as many related legacy privileges are consolidated.</p> <p><b>Note</b> When upgrading from an earlier release to Cisco APIC Release 5.0(x), you must reconfigure any rules, policies, or roles that use the more granular earlier privileges.</p>	<a href="#">Remapping of Legacy Privileges, on page 13</a>
Restricting Infra VLAN Traffic	To strengthen isolation between hypervisors in the fabric, you can restrict Infra VLAN traffic to only network paths specified by Infra security entry policies.	<a href="#">Restricting Infra VLAN Traffic, on page 207</a>



## CHAPTER 2

# Overview

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This chapter contains the following topic:

- [Overview, on page 3](#)

## Overview

The Cisco Application Centric Infrastructure (ACI) supports security features that can protect your network against degradation or failure and also against data loss or compromise resulting from intentional attacks and from unintended but damaging mistakes by well-meaning network users.

For information on core fabric services, see the *Cisco APIC Basic Configuration Guide*, which you can find on the [Cisco Application Policy Infrastructure Controller \(APIC\) documentation page](#).







## CHAPTER 3

# Access, Authentication, and Accounting

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- [Overview, on page 5](#)
- [Configuration, on page 28](#)
- [Recovering Cisco APIC Passwords and Accessing Special Logins, on page 41](#)

## Overview

### User Access, Authorization, and Accounting

Application Policy Infrastructure Controller (APIC) policies manage the authentication, authorization, and accounting (AAA) functions of the Cisco Application Centric Infrastructure (ACI) fabric. The combination of user privileges, roles, and domains with access rights inheritance enables administrators to configure AAA functions at the managed object level in a granular fashion. These configurations can be implemented using the REST API, the CLI, or the GUI.



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**Note** There is a known limitation where you cannot have more than 32 characters for the login domain name. In addition, the combined number of characters for the login domain name and the user name cannot exceed 64 characters.

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### Multiple Tenant Support

A core Application Policy Infrastructure Controller (APIC) internal data access control system provides multitenant isolation and prevents information privacy from being compromised across tenants. Read/write restrictions prevent any tenant from seeing any other tenant's configuration, statistics, faults, or event data. Unless the administrator assigns permissions to do so, tenants are restricted from reading fabric configuration, policies, statistics, faults, or events.

### User Access: Roles, Privileges, and Security Domains

The APIC provides access according to a user's role through role-based access control (RBAC). An Cisco Application Centric Infrastructure (ACI) fabric user is associated with the following:

- A predefined or custom role, which is a set of one or more privileges assigned to a user
- A set of privileges, which determine the managed objects (MOs) to which the user has access

- For each role, a privilege type: no access, read-only, or read-write
- One or more security domain tags that identify the portions of the management information tree (MIT) that a user can access

### Roles and Privileges

A privilege controls access to a particular function within the system. The ACI fabric manages access privileges at the managed object (MO) level. Every object holds a list of the privileges that can read from it and a list of the privileges that can write to it. All objects that correspond to a particular function will have the privilege for that function in its read or write list. Because an object might correspond to additional functions, its lists might contain multiple privileges. When a user is assigned a role that contains a privilege, the user is given read access to the associated objects whose read list specifies read access, and write access to those whose write list specifies write access.

As an example, 'fabric-equipment' is a privilege that controls access to all objects that correspond to equipment in the physical fabric. An object corresponding to equipment in the physical fabric, such as 'eqptBoard,' will have 'fabric-equipment' in its list of privileges. The 'eqptBoard' object allows read-only access for the 'fabric-equipment' privilege. When a user is assigned a role such as 'fabric-admin' that contains the privilege 'fabric-equipment,' the user will have access to those equipment objects, including read-only access to the 'eqptBoard' object.




---

**Note** Some roles contain other roles. For example, '-admin' roles such as tenant-admin, fabric-admin, access-admin are groupings of roles with the same base name. For example, 'access-admin' is a grouping of 'access-connectivity', 'access-equipment', 'access-protocol', and 'access-qos.' Similarly, tenant-admin is a grouping of roles with a 'tenant' base, and fabric-admin is a grouping of roles with a 'fabric' base.

The 'admin' role contains all privileges.

---

For more details about roles and privileges see [APIC Roles and Privileges Matrix](#).

### Security Domains

A security domain is a tag associated with a certain subtree in the ACI MIT object hierarchy. For example, the default tenant "common" has a domain tag `common`. Similarly, the special domain tag `all` includes the entire MIT object tree. An administrator can assign custom domain tags to the MIT object hierarchy. For example, an administrator could assign the "solar" domain tag to the tenant named solar. Within the MIT, only certain objects can be tagged as security domains. For example, a tenant can be tagged as a security domain but objects within a tenant cannot.




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**Note** Security Domain password strength parameters can be configured by creating **Custom Conditions** or by selecting **Any Three Conditions** that are provided.

---

Creating a user and assigning a role to that user does not enable access rights. It is necessary to also assign the user to one or more security domains. By default, the ACI fabric includes two special pre-created domains:

- `All`—allows access to the entire MIT
- `Infra`— allows access to fabric infrastructure objects/subtrees, such as fabric access policies



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**Note** For read operations to the managed objects that a user's credentials do not allow, a "DN/Class Not Found" error is returned, not "DN/Class Unauthorized to read." For write operations to a managed object that a user's credentials do not allow, an HTTP 401 Unauthorized error is returned. In the GUI, actions that a user's credentials do not allow, either they are not presented, or they are grayed out.

---

A set of predefined managed object classes can be associated with domains. These classes should not have overlapping containment. Examples of classes that support domain association are as follows:

- Layer 2 and Layer 3 network managed objects
- Network profiles (such as physical, Layer 2, Layer 3, management)
- QoS policies

When an object that can be associated with a domain is created, the user must assign domain(s) to the object within the limits of the user's access rights. Domain assignment can be modified at any time.

If a virtual machine management (VMM) domain is tagged as a security domain, the users contained in the security domain can access the correspondingly tagged VMM domain. For example, if a tenant named solar is tagged with the security domain called sun and a VMM domain is also tagged with the security domain called sun, then users in the solar tenant can access the VMM domain according to their access rights.

## User Lockout After Continuous Failed Attempts to Log in

Starting in the 4.2(4) release and 5.0(1) release, you can block a user from being able to log in after the user fails a configured number of login attempts. You can specify how many failed login attempts the user can have within a specific time period. If the user fails to log in too many times, then that user becomes unable to log in for a specified period of time.

This feature counts the failed login attempts both for local users that are in the Cisco Application Centric Infrastructure (ACI) database and for remote users who get authenticated with external authentication servers, such as RADIUS, LDAP, TACACS+, DUO Proxy, SAML, or RSA. A remote user who is locked out due to consecutive authentication failures using one external authentication server type will be locked out from all external authentication server types. For example, a user who is locked out after failing to log in using a RADIUS server will also be locked out when using an LDAP server. Authentications failing due to a AAA server being unreachable or down, or due to a bad SSH key, is not counted toward locking out a user; this feature only takes into account incorrect password entries.

A user who gets locked out from one Cisco Application Policy Infrastructure Controller (APIC) node in the cluster will be locked out from all nodes in the cluster, including the leaf switches and spine switches. A local user that does not exist in the Cisco ACI database cannot be locked out due to this feature.



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**Note** You cannot configure this feature using the CLI.

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## Access Rights Workflow Dependencies

The Cisco Application Centric Infrastructure (ACI) RBAC rules enable or restrict access to some or all of the fabric. For example, in order to configure a leaf switch for bare metal server access, the logged in administrator must have rights to the `infra` domain. By default, a tenant administrator does not have rights to the `infra`

domain. In this case, a tenant administrator who plans to use a bare metal server connected to a leaf switch could not complete all the necessary steps to do so. The tenant administrator would have to coordinate with a fabric administrator who has rights to the `infra` domain. The fabric administrator would set up the switch configuration policies that the tenant administrator would use to deploy an application policy that uses the bare metal server attached to an ACI leaf switch.

## AAA RBAC Roles and Privileges

The Application Policy Infrastructure Controller (APIC) provides the following AAA roles and privileges.



**Note** With Cisco APIC release 5.0(1), the number of privileges was reduced from earlier releases, as many related legacy privileges were consolidated. Earlier privileges were remapped to current privileges.



**Note** For each of the defined roles in Cisco APIC, the [APIC Roles and Privileges Matrix](#) shows which managed object classes can be written and which can be read.

- [Table 2: Privileges for Role: admin, on page 8](#)
- [Table 3: Privileges for Role: aaa, on page 9](#)
- [Table 4: Privileges for Role: access-admin, on page 9](#)
- [Table 5: Privileges for Role: fabric-admin, on page 9](#)
- [Table 6: Privileges for Role: nw-svc-admin, on page 10](#)
- [Table 7: Privileges for Role: nw-svc-params, on page 10](#)
- [Table 8: Privileges for Role: ops, on page 10](#)
- [Table 9: Privileges for Role: port-mgmt, on page 10](#)
- [Table 10: Privileges for Role: tenant-admin, on page 10](#)
- [Table 11: Privileges for Role: tenant-ext-admin, on page 12](#)
- [Table 12: Privileges for Role: vmm-admin, on page 13](#)

**Table 2: Privileges for Role: admin**

Role: admin	
Privilege	Description
admin	Provides full access to all of the features of the fabric. The admin privilege can be considered to be a union of all other privileges.

**Table 3: Privileges for Role: aaa**

<b>Role: aaa</b>	
<b>Privilege</b>	<b>Description</b>
aaa	Used for configuring authentication, authorization, accounting, and import/export policies.

**Table 4: Privileges for Role: access-admin**

<b>Role: access-admin</b>	
<b>Privilege</b>	<b>Description</b>
access-connectivity	Used for Layer 1 to 3 configuration under infra, static route configurations under a tenant's L3Out, management infra policies, and tenant ERSPAN policies.
access-equipment	Used for access port configuration.
access-protocol	Used for Layer 1 to 3 protocol configurations under infra, fabric-wide policies for NTP, SNMP, DNS, and image management, and operations-related access policies such as cluster policy and firmware policies.
access-qos	Used for changing CoPP and QoS-related policies.

**Table 5: Privileges for Role: fabric-admin**

<b>Role: fabric-admin</b>	
<b>Privilege</b>	<b>Description</b>
fabric-connectivity	Used for Layer 1 to 3 configuration under the fabric, firmware and deployment policies for raising warnings for estimating policy deployment impact, and atomic counter, diagnostic, and image management policies on leaf switches and spine switches.
fabric-equipment	Used for atomic counter, diagnostic, and image management policies on leaf switches and spine switches.
fabric-protocol	Used for Layer 1 to 3 protocol configurations under the fabric, fabric-wide policies for NTP, SNMP, DNS, and image management, ERSPAN and health score policies, and firmware management traceroute and endpoint tracking policies.

Table 6: Privileges for Role: nw-svc-admin

Role: nw-svc-admin	
Privilege	Description
nw-svc-policy	Used for managing Layer 4 to Layer 7 service devices and network service orchestration.

Table 7: Privileges for Role: nw-svc-params

Role: nw-svc-params	
Privilege	Description
nw-svc-params	Used for managing Layer 4 to Layer 7 service policies.

Table 8: Privileges for Role: ops

Role: ops	
Privilege	Description
ops	Used for viewing the policies configured including troubleshooting policies.  <b>Note</b> The <b>ops</b> role cannot be used for creating new monitoring and troubleshooting policies. Those policies need to be created by using the <b>admin</b> privilege, just like any other configurations in the Cisco APIC.

Table 9: Privileges for Role: port-mgmt

Role: port-mgmt	
Privilege	Description
port-mgmt	Used for assigning a node to a security domain. A user in a security domain with a Node Rule must also be assigned to domain <code>all</code> with the role of <code>port-mgmt</code> .

Table 10: Privileges for Role: tenant-admin

Role: tenant-admin	
Privilege	Description
aaa	Used for configuring authentication, authorization, accounting and import/export policies.
access-connectivity	Used for Layer 1 to 3 configuration under <code>infra</code> , static route configurations under a tenant's <code>L3Out</code> , management <code>infra</code> policies, and tenant <code>ERSPAN</code> policies.

<b>Role: tenant-admin</b>	
<b>Privilege</b>	<b>Description</b>
access-equipment	Used for access port configuration.
access-protocol	Used for Layer 1 to 3 protocol configurations under infra, fabric-wide policies for NTP, SNMP, DNS, and image management, and operations-related access policies such as cluster policy and firmware policies.
access-qos	Used for changing CoPP and QoS-related policies.
fabric-connectivity	Used for Layer 1 to 3 configuration under the fabric, firmware and deployment policies for raising warnings for estimating policy deployment impact, and atomic counter, diagnostic, and image management policies on leaf switches and spine switches.
fabric-equipment	Used for atomic counter, diagnostic, and image management policies on leaf switches and spine switches.
fabric-protocol	Used for Layer 1 to 3 protocol configurations under the fabric, fabric-wide policies for NTP, SNMP, DNS, and image management, ERSPAN and health score policies, and firmware management traceroute and endpoint tracking policies.
nw-svc-policy	Used for managing Layer 4 to Layer 7 service devices and network service orchestration.
ops	Used for viewing the policies configured including troubleshooting policies.  <b>Note</b> The <b>ops</b> role cannot be used for creating new monitoring and troubleshooting policies. Those policies need to be created by using the <b>admin</b> privilege, just like any other configurations in the Cisco APIC.
tenant-connectivity	Used for Layer 1 to 3 connectivity changes, including bridge domains, subnets, and VRFs; for atomic counter, diagnostic, and image management policies on leaf switches and spine switches; tenant in-band and out-of-band management connectivity configurations; and debugging/monitoring policies such as atomic counters and health score.
tenant-epg	Used for managing tenant configurations such as deleting/creating endpoint groups.
tenant-ext-connectivity	Used for write access firmware policies; managing tenant L2Out and L3Out configurations; and debugging/monitoring/observer policies such as traceroute, ping, oam, and eptrk.

<b>Role: tenant-admin</b>	
<b>Privilege</b>	<b>Description</b>
tenant-ext-protocol	Used for managing tenant external Layer 1 to 3 protocols, including BGP, OSPF, PIM, and IGMP, and for debugging/monitoring/observer policies such as traceroute, ping, oam, and eprk. Generally only used for write access for firmware policies.
tenant-network-profile	Used for managing tenant configurations, such as deleting and creating network profiles, and deleting and creating endpoint groups.
tenant-protocol	Used for managing configurations for Layer 1 to 3 protocols under a tenant, for tenant traceroute policies, and as write access for firmware policies.
tenant-qos	Used for QoS-related configurations for a tenant.
tenant-security	Used for contract-related configurations for a tenant.
vmm-policy	Used for managing policies for virtual machine networking, such as authentication and connectivity.

Table 11: Privileges for Role: tenant-ext-admin

<b>Role: tenant-ext-admin</b>	
<b>Privilege</b>	<b>Description</b>
tenant-connectivity	Used for Layer 1 to 3 connectivity changes, including bridge domains, subnets, and VRFs; for atomic counter, diagnostic, and image management policies on leaf switches and spine switches; tenant in-band and out-of-band management connectivity configurations; and debugging/monitoring policies such as atomic counters and health score.
tenant-epg	Used for managing tenant configurations such as deleting/creating endpoint groups, VRFs, and bridge domains.
tenant-ext-connectivity	Used for write access firmware policies; managing tenant L2Out and L3Out configurations; and debugging/monitoring/observer policies such as traceroute, ping, oam, and eprk.
tenant-ext-protocol	Used for managing tenant external Layer 1 to 3 protocols, including BGP, OSPF, PIM, and IGMP, and for debugging/monitoring/observer policies such as traceroute, ping, oam, and eprk. Generally only used for write access for firmware policies.
tenant-network-profile	Used for managing tenant configurations, such as deleting and creating network profiles, and deleting and creating endpoint groups.
tenant-protocol	Used for managing configurations for Layer 1 to 3 protocols under a tenant, for tenant traceroute policies, and as write access for firmware policies.



<b>Role: tenant-ext-admin</b>	
<b>Privilege</b>	<b>Description</b>
tenant-qos	Used for QoS-related configurations for a tenant.
tenant-security	Used for contract-related configurations for a tenant.
vmm-policy	Used for managing policies for virtual machine networking, such as authentication and connectivity.

**Table 12: Privileges for Role: vmm-admin**

<b>Role: vmm-admin</b>	
<b>Privilege</b>	<b>Description</b>
vmm-policy	Used for managing policies for virtual machine networking, such as authentication and connectivity.

## Remapping of Legacy Privileges

With Cisco APIC Release 5.0(1), the number of privileges is reduced from earlier releases, as many related legacy privileges are consolidated. The following tables show the mapping of earlier privileges to the current privileges.

- [Table 13: Privilege: admin, on page 14](#)
- [Table 14: Privilege: aaa, on page 14](#)
- [Table 15: Privilege: access-connectivity, on page 14](#)
- [Table 16: Privilege: access-equipment, on page 14](#)
- [Table 17: Privilege: access-protocol, on page 15](#)
- [Table 18: Privilege: access-qos, on page 15](#)
- [Table 19: Privilege: fabric-connectivity, on page 15](#)
- [Table 20: Privilege: fabric-equipment, on page 15](#)
- [Table 21: Privilege: fabric-protocol, on page 16](#)
- [Table 22: Privilege: nw-svc-params, on page 16](#)
- [Table 23: Privilege: nw-svc-policy, on page 16](#)
- [Table 24: Privilege: ops, on page 16](#)
- [Table 25: Privilege: tenant-connectivity, on page 16](#)
- [Table 26: Privilege: tenant-epg, on page 17](#)
- [Table 27: Privilege: tenant-ext-connectivity, on page 17](#)
- [Table 28: Privilege: tenant-ext-protocol, on page 17](#)

- [Table 29: Privilege: tenant-network-profile, on page 17](#)
- [Table 30: Privilege: tenant-protocol, on page 18](#)
- [Table 31: Privilege: tenant-qos, on page 18](#)
- [Table 32: Privilege: tenant-security, on page 18](#)
- [Table 33: Privilege: vmm-policy, on page 18](#)

**Table 13: Privilege: admin**

Previous Privileges	Current Privilege
admin	admin

**Table 14: Privilege: aaa**

Previous Privileges	Current Privilege
aaa	aaa

**Table 15: Privilege: access-connectivity**

Previous Privileges	Current Privilege
access-connectivity-11	access-connectivity
access-connectivity-12	
access-connectivity-13	
access-connectivity-mgmt	
access-connectivity-util	

**Table 16: Privilege: access-equipment**

Previous Privileges	Current Privilege
access-equipment	access-equipment

**Table 17: Privilege: access-protocol**

Previous Privileges	Current Privilege
access-protocol-l1	access-protocol
access-protocol-l2	
access-protocol-l3	
access-protocol-mgmt	
access-protocol-ops	
access-protocol-util	

**Table 18: Privilege: access-qos**

Previous Privileges	Current Privilege
access-qos	access-qos

**Table 19: Privilege: fabric-connectivity**

Previous Privileges	Current Privilege
fabric-connectivity-l1	fabric-connectivity
fabric-connectivity-l2	
fabric-connectivity-l3	
fabric-connectivity-mgmt	
fabric-connectivity-util	

**Table 20: Privilege: fabric-equipment**

Previous Privileges	Current Privilege
fabric-equipment	fabric-equipment

**Table 21: Privilege: fabric-protocol**

Previous Privileges	Current Privilege
fabric-protocol-l1	fabric-protocol
fabric-protocol-l2	
fabric-protocol-l3	
fabric-protocol-mgmt	
fabric-protocol-ops	
fabric-protocol-util	

**Table 22: Privilege: nw-svc-params**

Previous Privileges	Current Privilege
nw-svc-params	nw-svc-params

**Table 23: Privilege: nw-svc-policy**

Previous Privileges	Current Privilege
nw-svc-devshare	nw-svc-policy
nw-svc-params	
nw-svc-policy	

**Table 24: Privilege: ops**

Previous Privileges	Current Privilege
ops	ops

**Table 25: Privilege: tenant-connectivity**

Previous Privileges	Current Privilege
tenant-connectivity-util	tenant-connectivity
tenant-connectivity-l2	
tenant-connectivity-l3	
tenant-connectivity-mgmt	
tenant-connectivity-util	

**Table 26: Privilege: tenant-epg**

Previous Privileges	Current Privilege
tenant-epg	tenant-epg

**Table 27: Privilege: tenant-ext-connectivity**

Previous Privileges	Current Privilege
tenant-ext-connectivity-l1	tenant-ext-connectivity
tenant-ext-connectivity-l2	
tenant-ext-connectivity-l3	
tenant-ext-connectivity-mgmt	
tenant-ext-connectivity-util	

**Table 28: Privilege: tenant-ext-protocol**

Previous Privileges	Current Privilege
tenant-ext-protocol-l1	tenant-ext-protocol
tenant-ext-protocol-l2	
tenant-ext-protocol-l3	
tenant-ext-protocol-mgmt	
tenant-ext-protocol-util	

**Table 29: Privilege: tenant-network-profile**

Previous Privileges	Current Privilege
tenant-network-profile	tenant-network-profile

**Table 30: Privilege: tenant-protocol**

Previous Privileges	Current Privilege
tenant-protocol-l1	tenant-protocol
tenant-protocol-l2	
tenant-protocol-l3	
tenant-protocol-mgmt	
tenant-protocol-ops	
tenant-protocol-util	

**Table 31: Privilege: tenant-qos**

Previous Privileges	Current Privilege
tenant-qos	tenant-qos

**Table 32: Privilege: tenant-security**

Previous Privileges	Current Privilege
tenant-security	tenant-security

**Table 33: Privilege: vmm-policy**

Previous Privileges	Current Privilege
vmm-connectivity	vmm-policy
vmm-ep	
vmm-policy	
vmm-protocol-ops	
vmm-security	

## Custom Roles

You can create custom roles and assign privileges to the roles. The interface internally assigns one or more privileges to all managed object classes. In an XML model, privileges are assigned in an access attribute. Privilege bits are assigned at compile time and apply per class, and not per instance or object of the class.

In addition to the 45 privilege bits, the "aaa" privilege bit applies to all AAA-subsystem configuration and read operations. The following table provides a matrix of the supported privilege combinations. The rows in the table represent Cisco Application Centric Infrastructure (ACI) modules and the columns represent functionality for a given module. A value of "Yes" in a cell indicates that the functionality for the module is accessible and there exists a privilege bit to access that functionality. An empty cell indicates that the particular

functionality for module is not accessible by any privilege bit. See the privilege bit descriptions to learn what each bit does.

	Connectivity	OS	Security	Application	Fault	Stats	Provider	Service Profile	Service Chain
VMM	Yes		Yes		Yes	Yes	Yes		
Fabric	Yes	Yes	Yes	Yes	Yes	Yes	Yes		
External	Yes	Yes	Yes		Yes	Yes			Yes
Tenant	Yes	Yes	Yes	EPG, NP	Yes	Yes			Yes
Infra	Yes	Yes	Yes	Yes	Yes	Yes			Yes
Ops					Yes	Yes			
Storage	Yes	Yes	Yes	Yes	Yes	Yes			
Network Service	Yes	Yes	Yes	Yes	Yes	Yes		Yes	

## Selectively Expose Physical Resources across Security Domains

A fabric-wide administrator uses RBAC rules to selectively expose physical resources to users that otherwise are inaccessible because they are in a different security domain.

For example, if a user in tenant Solar needs access to a virtual machine management (VMM) domain, the fabric-wide admin could create an RBAC rule to allow this. The RBAC rule is comprised of these two parts: the distinguished name (DN) that locates the object to be accessed plus the name of the security domain that contains the user who will access the object. So, in this example, when designated users in the security domain Solar are logged in, this rule gives them access to the VMM domain as well as all its child objects in the tree. To give users in multiple security domains access to the VMM domain, the fabric-wide administrator would create an RBAC rule for each security domain that contains the DN for the VMM domain plus the security domain.



**Note** While an RBAC rule exposes an object to a user in a different part of the management information tree, it is not possible to use the CLI to navigate to such an object by traversing the structure of the tree. However, as long as the user knows the DN of the object included in the RBAC rule, the user can use the CLI to locate it via an MO find command.

## Enable Sharing of Services across Security Domains

A fabric-wide administrator uses RBAC rules to provision trans-tenant EPG communications that enable shared services across tenants.

## APIC Local Users

An administrator can choose not to use external AAA servers but rather configure users on the APIC itself. These users are called APIC-local users.

At the time a user sets their password, the APIC validates it against the following criteria:

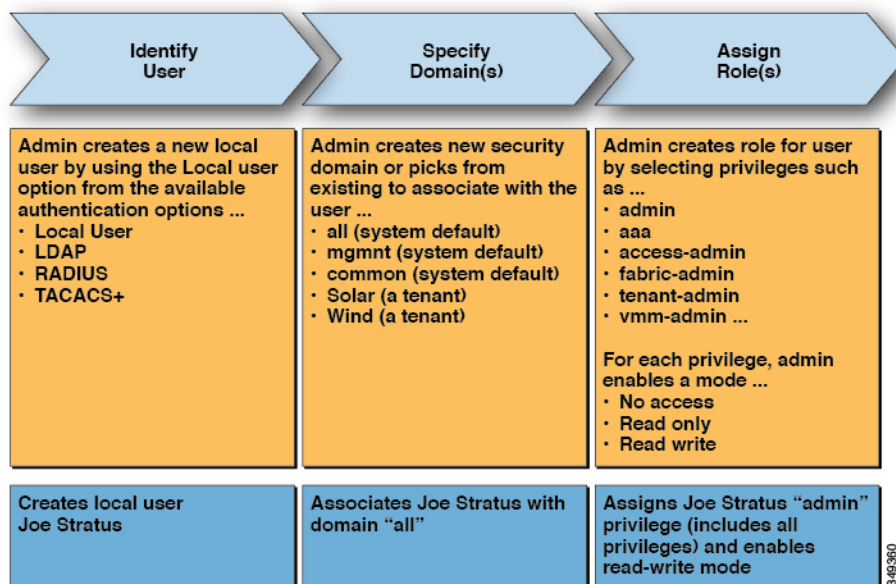
- Minimum password length is 8 characters.
- Maximum password length is 64 characters.
- Has fewer than three consecutive repeated characters.
- Must have characters from at least three of the following characters types: lowercase, uppercase, digit, symbol.
- Does not use easily guessed passwords.
- Cannot be the username or the reverse of the username.
- Cannot be any variation of cisco, isco or any permutation of these characters or variants obtained by changing the capitalization of letters therein.

Cisco ACI uses a crypt library with a SHA256 one-way hash for storing passwords. At rest hashed passwords are stored in an encrypted filesystem. The key for the encrypted filesystem is protected using the Trusted Platform Module (TPM).

The APIC also enables administrators to grant access to users configured on externally managed authentication Lightweight Directory Access Protocol (LDAP), RADIUS, TACACS+, or SAML servers. Users can belong to different authentication systems and can log in simultaneously to the APIC.

The following figure shows how the process works for configuring an admin user in the local APIC authentication database who has full access to the entire ACI fabric.

**Figure 1: APIC Local User Configuration Process**

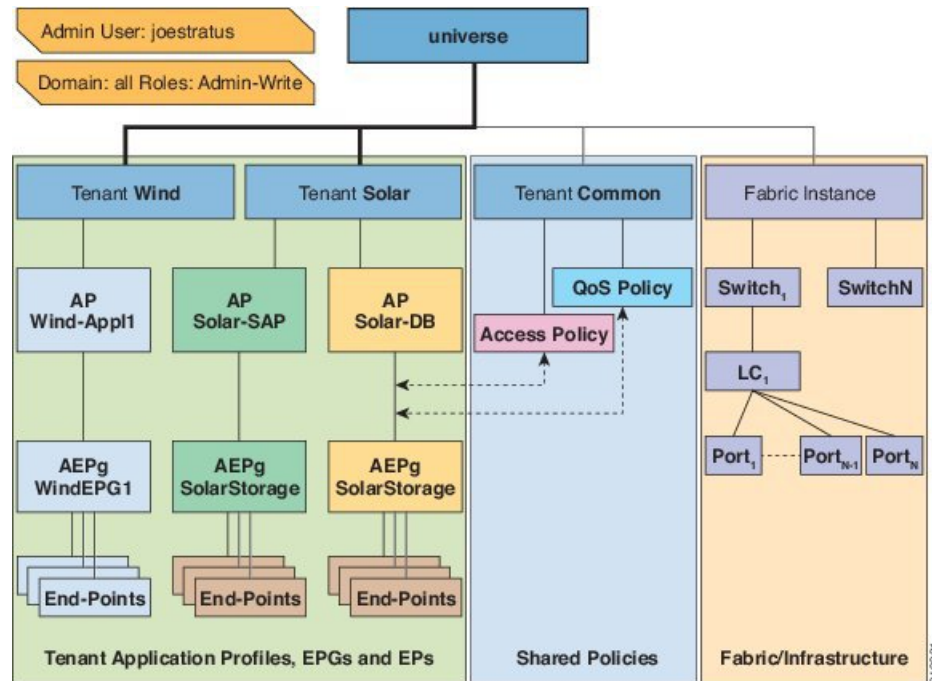


**Note** The security domain "all" represents the entire Managed Information Tree (MIT). This domain includes all policies in the system and all nodes managed by the APIC. Tenant domains contain all the users and managed objects of a tenant. Tenant administrators should not be granted access to the "all" domain.



The following figure shows the access that the admin user Joe Stratus has to the system.

**Figure 2: Result of Configuring Admin User for "all" Domain**



The user Joe Stratus with read-write "admin" privileges is assigned to the domain "all" which gives him full access to the entire system.

## OTP-Based Two-Factor Authentication for Local Users

A fabric admin user can enable the one-time password (OTP) feature for a local user. A one-time password changes every 30 seconds for enhanced security. After the admin enables OTP, Cisco Application Policy Infrastructure Controller (APIC) generates a random human-readable 16 binary octet that is a base32 OTP key. This OTP key is used to generate the OTP for the user, which is used for two-factor authentication.

Cisco APIC supports the following security platforms for use with two-factor authentication:

- Duo Security, with the Duo Mobile app
- Google, with the Google Authenticator app (only with Android and Apple iOS smartphones)



**Note** You must download the indicated app from the appropriate app store.

These security platforms do not act as a repository for user identities. The platforms offer two-factor authentication on top of an organization's existing authentication, which could be on-premises or cloud-based. Two-factor authentication occurs once the user has finished the authentication with the organization's primary authentication source.

The platforms support three types of two-factor authentication methods after you complete authentication with the primary authentication source:

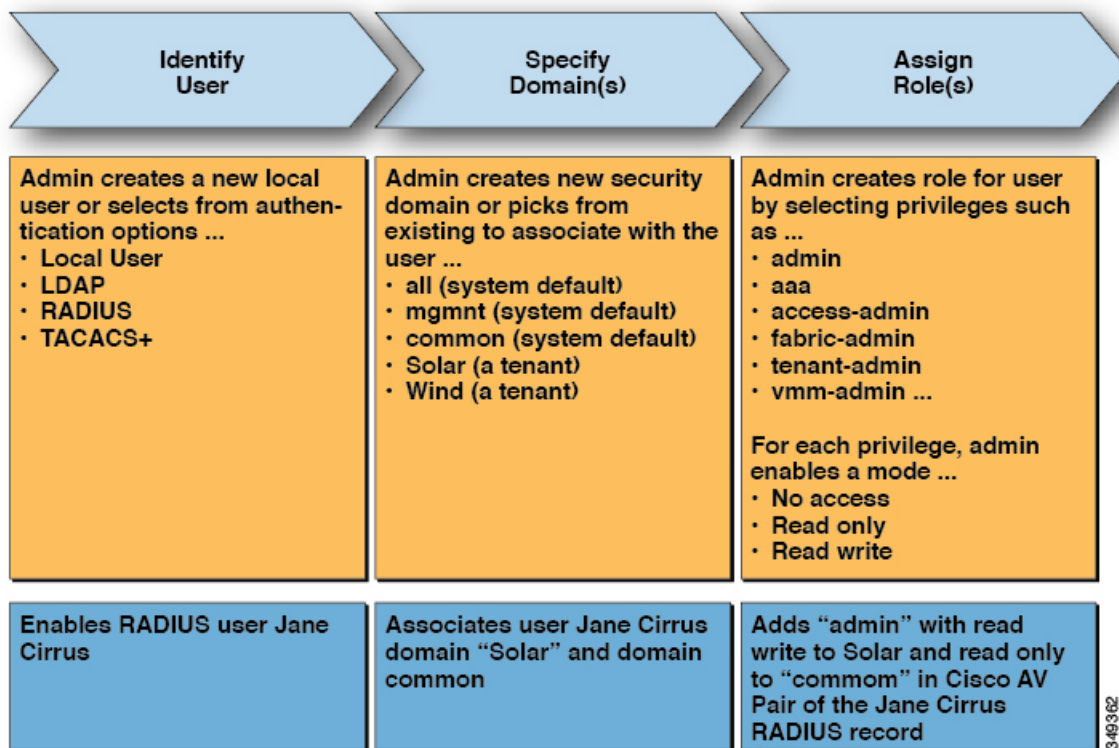
- Notification push on mobile using the appropriate mobile app on smartphones.

- Phone call on your registered phone or mobile numbers.
- Passcode that is generated on the appropriate mobile app.

## Externally Managed Authentication Server Users

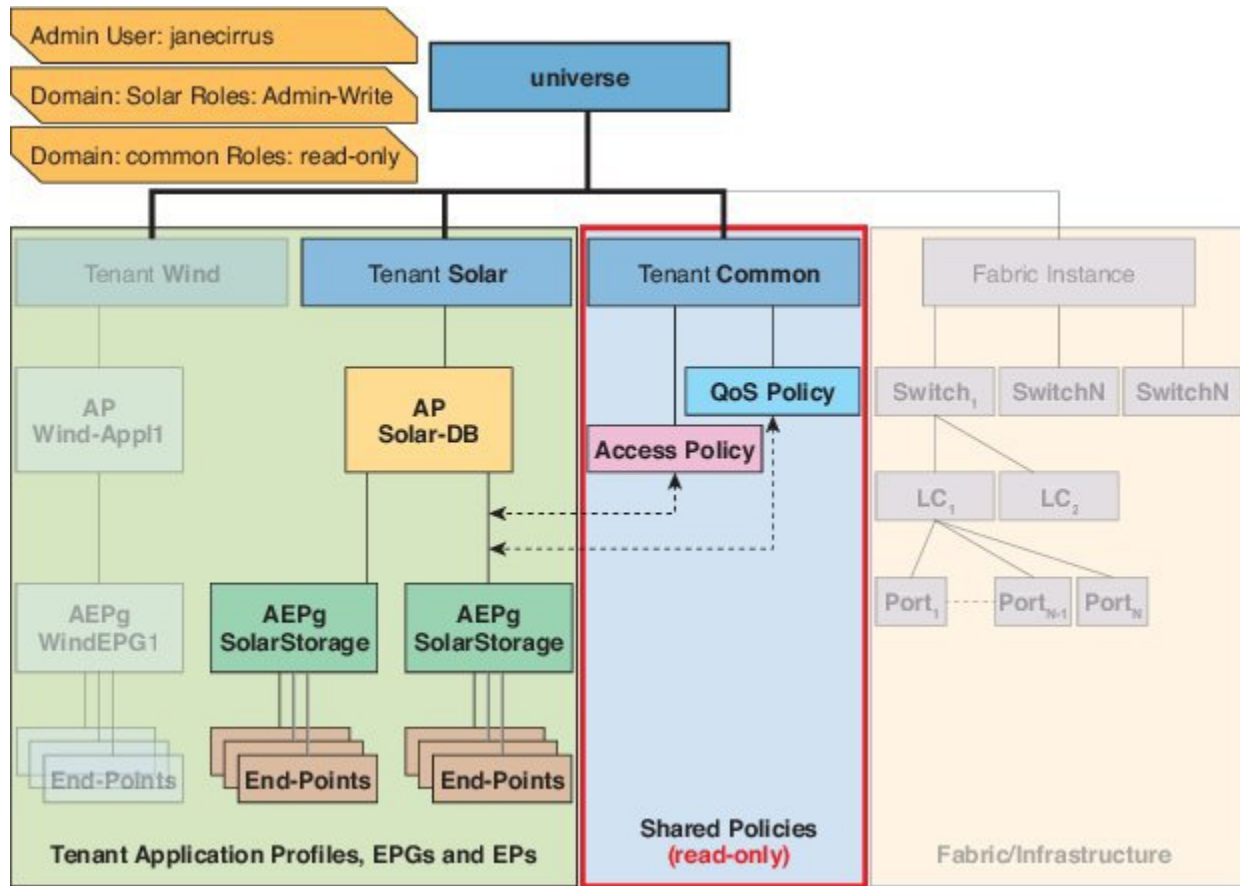
The following figure shows how the process works for configuring an admin user in an external RADIUS server who has full access to the tenant Solar.

Figure 3: Process for Configuring Users on External Authentication Servers



The following figure shows the access the admin user Jane Cirrus has to the system.

Figure 4: Result of Configuring Admin User for Tenant Solar



In this example, the Solar tenant administrator has full access to all the objects contained in the Solar tenant as well as read-only access to the tenant Common. Tenant admin Jane Cirrus has full access to the tenant Solar, including the ability to create new users in tenant Solar. Tenant users are able to modify configuration parameters of the ACI fabric that they own and control. They also are able to read statistics and monitor faults and events for the entities (managed objects) that apply to them such as endpoints, endpoint groups (EPGs) and application profiles.

In the example above, the user Jane Cirrus was configured on an external RADIUS authentication server. To configure an AV Pair on an external authentication server, add a Cisco AV Pair to the existing user record. The Cisco AV Pair specifies the Role-Based Access Control (RBAC) roles and privileges for the user on the APIC. The RADIUS server then propagates the user privileges to the APIC controller.

In the example above, the configuration for an open radius server (/etc/raddb/users) is as follows:

```
janecirrus Cleartext-Password := "<password>"
Cisco-avpair = "shell:domains = solar/admin/,common//read-all(16001) "
```

This example includes the following elements:

- janecirrus is the tenant administrator
- solar is the tenant
- admin is the role with write privileges

- `common` is the tenant-common subtree that all users should have read-only access to
- `read-all` is the role with read privileges

## Cisco AV Pair Format

The Cisco APIC requires that an administrator configure a Cisco AV Pair on an external authentication server and only looks for one AV pair string. To do so, an administrator adds a Cisco AV pair to the existing user record. The Cisco AV pair specifies the APIC required RBAC roles and privileges for the user.

In order for the AV pair string to work, it must be formatted as follows:

```
shell:domains =
ACI_Security_Domain_1/ACI_Write_Role_1|ACI_Write_Role_2|ACI_Write_Role_3/ACI_Read_Role_1|ACI_Read_Role_2,
ACI_Security_Domain_2/ACI_Write_Role_1|ACI_Write_Role_2|ACI_Write_Role_3/ACI_Read_Role_1|ACI_Read_Role_2,
ACI_Security_Domain_3/ACI_Write_Role_1|ACI_Write_Role_2|ACI_Write_Role_3/ACI_Read_Role_1|ACI_Read_Role_2
```

- **shell:domains=** - Required so that ACI reads the string correctly. This must always prepend the shell string.
- **ACI\_Security\_Domain\_1/admin** - Grants admin read only access to the tenants in this security domain.
- **ACI\_Security\_Domain\_2/admin** - Grants admin write access to the tenants in this security domain.
- **ACI\_Security\_Domain\_3/read-all** - Grants read-all write access to the tenants in this security domain.




---

**Note** /s separate the security domain, write, read sections of the string. |s separate multiple write or read roles within the same security domain.

---




---

**Note** Starting with Cisco APIC release 2.1, if no UNIX ID is provided in AV Pair, the APIC allocates the unique UNIX user ID internally.

---

The APIC supports the following regexes:

```
shell:domains\\s*[:]\s*((\\S+?/\\S*?/\\S*?) (, \\S+?/\\S*?/\\S*?) {0,31}) (\\ (\\d+\\))$
shell:domains\\s*[:]\s*((\\S+?/\\S*?/\\S*?) (, \\S+?/\\S*?/\\S*?) {0,31})$
```

### Examples:

- Example 1: A Cisco AV Pair that contains a single Login domain with only writeRoles:

```
shell:domains=ACI_Security_Domain_1/Write_Role_1|Write_Role_2/
```

- Example 2: A Cisco AV Pair that contains a single Login domain with only readRoles:

```
shell:domains=Security_Domain_1//Read_Role_1|Read_Role_2
```



**Note** The "/" character is a separator between writeRoles and readRoles per Login domain and is required even if only one type of role is to be used.

The Cisco AVpair string is case sensitive. Although a fault may not be seen, using mismatching cases for the domain name or roles could lead to unexpected privileges being given.

### AV Pair GUI Configuration

The security domain is defined in the ACI GUI under **Admin > AAA > Security Management > Security Domains** and assigned to a tenant under **Tenants > Tenant\_Name > Policy**.

A security domain must have either a read or write role. These roles are defined in **APIC > Admin > Security Management > Roles**. If a role is input into the write section it automatically grants read privileges of the same level so there is no need to have ACI\_Security\_Domain\_1/admin/admin.

## Change Remote User Role

User-privileges can be modified “dynamically”, which allows the user to request for a role-change, and is allowed or denied the requested role based on information stored locally or remotely.

The role-change is only supported through the Cisco ACS server and can be done by role assignment based on explicit "request".

The ACI fabric supports external authentication using Radius, TACACS+ and LDAP protocols. Both the above-mentioned methods assume that the remote authentication server has components to support the role-change functionality.

The Cisco Secure ACS server provides the remote authentication, authorization and accounting features for the TACACS+ protocol.

Rules are matched, either with **Default Device Admin** or **Default Network Access Service**.

In the Authorization, another set of rules are configured:

- **AVPairOps**: matches the tacacs+ username and AVPair value (cisco-av-pair\*newrole). If the rule matches, the ACI\_OPS shell-profile is returned
- **NoAVPair**: matches only the tacacs+ username and return ACI\_ADMIN shell profile on match
- **opsuser**: matches only the protocol and returns ACI\_OPS shell profile

### Change the Remote User Role Using the GUI

#### Before you begin

Roles must first be configured on the Cisco ASC Server to match the AVPairs and selected shell-authorization-profile based on the match.

#### Procedure

- Step 1** Create an ASC Authorization Policy navigate to **Access Policies > Access Services > Default Device Admin Identity** and perform the following steps:

**Note** Shell Profile is configured with CiscoAVPair , which is used to Authorize the User.

a) Add the condition to **TACACS+:AVPair equals cisco-av-pair\*** and click **OK**.

**Note** The user is authorized with the **cisco-av-pair** role by default.

b) Add the condition to **TACACS+:AVPair equals cisco-av-pair\*readall** and click **OK**.

**Note** The keyword **readall** is used in APIC to change the Role from **default** Role to **readall** Role (read-all is configured in Shell-Profile).

**Step 2** Log in to the APIC GUI, click the **welcome, <login\_name>** drop-down list and choose Change Remote User Role.

**Step 3** In the Change Remote User Role dialog box, enter the information in the **User Name, Password, and New Role** fields and click **Submit**.

The GUI will refresh with the new role applied.

**Note** To return to the parent role, open the Change Remote User Role dialog box again and enter the information for **User Name** and **Password** but leave the **New Role** field blank.

## Change the Remote User Role Using REST API

### Before you begin

Roles must first be configured on the Cisco ASC Server to match the AVPairs and selected shell-authorization-profile based on the match.

The user logs in with the user-name **apicadmin** and password.

### Procedure

**Step 1** Change to a new role:

#### Example:

```
<!-- api/requestNewRole/json -->
<aaaChangeRole>
<attributes userName="apic#tacacs" apicadmin="pwd Ins3965!" role="newrole"/>
```

**Step 2** Return to the original role:

#### Example:

```
<!-- api/requestNewRole/json -->
<aaaChangeRole>
<attributes userName="apic#tacacs" apicadmin="pwd Ins3965!" role=""/>
```

## About Signature-Based Transactions

The APIC controllers in a Cisco ACI fabric offer different methods to authenticate users.

The primary authentication method uses a username and password and the APIC REST API returns an authentication token that can be used for future access to the APIC. This may be considered insecure in a situation where HTTPS is not available or enabled.

Another form of authentication that is offered utilizes a signature that is calculated for every transaction. The calculation of that signature uses a private key that must be kept secret in a secure location. When the APIC receives a request with a signature rather than a token, the APIC utilizes an X.509 certificate to verify the signature. In signature-based authentication, every transaction to the APIC must have a newly calculated signature. This is not a task that a user should do manually for each transaction. Ideally this function should be utilized by a script or an application that communicates with the APIC. This method is the most secure as it requires an attacker to crack the RSA/DSA key to forge or impersonate the user credentials.



---

**Note** Additionally, you must use HTTPS to prevent replay attacks.

---

Before you can use X.509 certificate-based signatures for authentication, verify that the following pre-requisite tasks are completed:

1. Create an X.509 certificate and private key using OpenSSL or a similar tool.
2. Create a local user on the APIC. (If a local user is already available, this task is optional).
3. Add the X.509 certificate to the local user on the APIC.

## Guidelines and Limitations

Follow these guidelines and limitations:

- Local users are supported. Remote AAA users are not supported.
- The APIC GUI does not support the certificate authentication method.
- WebSockets and eventchannels do not work for X.509 requests.
- Certificates signed by a third party are not supported. Use a self-signed certificate.

## Accounting

Cisco Application Centric Infrastructure (ACI) fabric accounting is handled by these two managed objects that are processed by the same mechanism as faults and events:

- The `aaaSessionLR` managed object tracks user account login and logout sessions on the Cisco Application Policy Infrastructure Controller (APIC) and switches, and token refresh. The Cisco ACI fabric session alert feature stores information such as the following:
  - Username
  - IP address initiating the session
  - Type (telnet, HTTPS, REST, and so on)
  - Session time and length
- Token refresh: A user account login event generates a valid active token which is required in order for the user account to exercise its rights in the Cisco ACI fabric.




---

**Note** Token expiration is independent of login; a user could log out but the token expires according to the duration of the timer value it contains.

---

- The `aaaModLR` managed object tracks the changes users make to objects and when the changes occurred.
- If the AAA server is not pingable, it is marked unavailable and a fault is seen.

Both the `aaaSessionLR` and `aaaModLR` event logs are stored in Cisco APIC shards. After the data exceeds the pre-set storage allocation size, it overwrites records on a first-in first-out basis.




---

**Note** In the event of a destructive event such as a disk crash or a fire that destroys a Cisco APIC cluster node, the event logs are lost; event logs are not replicated across the cluster.

---

The `aaaModLR` and `aaaSessionLR` managed objects can be queried by class or by distinguished name (DN). A class query provides all the log records for the whole fabric. All `aaaModLR` records for the whole fabric are available from the GUI at the **Fabric > Inventory > POD > History > Audit Log** section. The Cisco APIC GUI **History > Audit Log** options enable viewing event logs for a specific object identified in the GUI.

The standard syslog, callhome, REST query, and CLI export mechanisms are fully supported for `aaaModLR` and `aaaSessionLR` managed object query data. There is no default policy to export this data.

There are no pre-configured queries in the Cisco APIC that report on aggregations of data across a set of objects or for the entire system. A fabric administrator can configure export policies that periodically export `aaaModLR` and `aaaSessionLR` query data to a syslog server. Exported data can be archived periodically and used to generate custom reports from portions of the system or across the entire set of system logs.

## Routed Connectivity to External Networks as a Shared Service Billing and Statistics

The Cisco Application Policy Infrastructure Controller (APIC) can be configured to collect byte count and packet count billing statistics from a port configured for routed connectivity to external networks as a shared service. The external networks are represented as external L3Out endpoint group (l3extInstP managed object) in Cisco Application Centric Infrastructure (ACI). Any EPG in any tenant can share an external L3Out EPG for routed connectivity to external networks. Billing statistics can be collected for each EPG in any tenant that uses an external L3Out EPG as a shared service. The leaf switch where the external L3Out EPG is provisioned forwards the billing statistics to the Cisco APIC where they are aggregated. Accounting policies can be configured to export these billing statistics periodically to a server.

# Configuration

## Configuring a Local User

In the initial configuration script, the admin account is configured and the admin is the only user when the system starts. The APIC supports a granular, role-based access control system where user accounts can be created with various roles including non-admin users with fewer privileges.



## Configuring a Local User Using the GUI

### Before you begin

- The ACI fabric is installed, APIC controllers are online, and the APIC cluster is formed and healthy.
- As appropriate, the security domain(s) that the user will access are defined. For example, if the new user account will be restricted to accessing a tenant, the tenant domain is tagged accordingly.
- An APIC user account is available that will enable the following:
  - Creating the TACACS+ provider.
  - Creating the local user account in the target security domain(s). If the target domain is `all`, the login account used to create the new local user must be a fabric-wide administrator that has access to `all`. If the target domain is a tenant, the login account used to create the new local user must be a tenant administrator that has full read write access rights to the target tenant domain.

### Procedure

---

- Step 1** On the menu bar, choose **Admin > AAA**.
- Step 2** In the **Navigation** pane, click **Users**.  
In the **Work** pane, verify that you are in the **Local Users** tab.
- Step 3** In the **Work** pane, click the task icon drop-down list and select **Create Local User**.
- Step 4** In the **STEP 1 > User Identity** dialog box, perform the following actions:

- a) In the **Login ID** field, add an ID.

The login ID must meet the following guidelines:

- Must be unique within APIC.
- Must begin with a letter.
- Can contain between 1 and 32 characters.
- Can include alphanumeric characters, underscores, dashes, and dots.

After creating a user account, you cannot change the login ID. You must delete the user account and create a new one.

- b) In the **Password** field, enter the password.

At the time a user sets their password, the APIC validates it against the following criteria:

- Minimum password length is 8 characters.
- Maximum password length is 64 characters.
- Has fewer than three consecutive repeated characters.
- Must have characters from at least three of the following characters types: lowercase, uppercase, digit, symbol.
- Does not use easily guessed passwords.

- Cannot be the username or the reverse of the username.
  - Cannot be any variation of cisco, isco or any permutation of these characters or variants obtained by changing the capitalization of letters therein.
- c) In the **Confirm Password** field, confirm the password.
  - d) (Optional) For Certificate based authentication, in the **User Certificate Attribute** field, enter the user identity from the authentication certificate.
  - e) Click **Next**.

**Step 5** You can activate or deactivate the user account by using the **Account Status** control, and you can set an expiration date by using the **Account Expires** control.

**Step 6** In the **STEP 2 > Security** dialog box, under **Security Domain**, choose the desired security domain for the user, and click **Next**.

**Step 7** In the **STEP 3 > Roles** dialog box, perform the following actions:

- a) Click the + to associate the user with a domain.
- b) From the drop-down lists, choose a **Role Name** and a **Role Privilege Type** for the user.
- c) click **Update**

You can provide read-only or read/write privileges.

**Step 8** click **Finish**

## Configuring SSH Public Key Authentication Using the GUI

### Before you begin

- Create a local user account in the target security domain(s). If the target domain is `all`, the login account used to create the new local user must be a fabric-wide administrator that has access to `all`. If the target domain is a tenant, the login account used to create the new local user must be a tenant administrator that has full read write access rights to the target tenant domain.
- Generate a public key using the Unix command **ssh-keygen**.

The default login domain must be set to **local**

### Procedure

**Step 1** On the menu bar, choose **ADMIN > Users** and confirm you are in the **Local Users** tab.

**Step 2** In the **Navigation** pane, click the name of the user that you previously created.

**Step 3** In the **Work** pane, expand the **SSH Keys** table, and insert the following information:

- a) In the **Name** field, enter a name for the key.
- b) In the **Key** field, insert the public key previously created. Click **Update**.

**Note** To create the SSH Private Key File for downloading to a remote location then in the menu bar, expand **Firmware > Download Tasks**.

## Configuring a Local User Using the NX-OS Style CLI

### Procedure

**Step 1** In the NX-OS CLI, start in configuration mode, shown as follows:

#### Example:

```
apic1# configure
apic1(config)#
```

**Step 2** Create a new user, shown as follows:

#### Example:

```
apic1(config)# username
WORD          User name (Max Size 28)
admin
cli-user
jigarshah
test1
testUser

apic1(config)# username test
apic1(config-username)#
account-status      Set The status of the locally-authenticated user account.
certificate         Create AAA user certificate in X.509 format.
clear-pwd-history   Clears the password history of a locally-authenticated user
domain             Create the AAA domain to which the user belongs.
email              Set The email address of the locally-authenticated user.
exit               Exit from current mode
expiration          If expires enabled, Set expiration date of locally-authenticated user
account.
expires            Enable expiry for locally-authenticated user account
fabric             show fabric related information
first-name         Set the first name of the locally-authenticated user.
last-name          Set The last name of the locally-authenticated user.
no                Negate a command or set its defaults
password           Set The system user password.
phone             Set The phone number of the locally-authenticated user.
pwd-lifetime       Set The lifetime of the locally-authenticated user password.
pwd-strength-check Enforces the strength of the user password
show              Show running system information
ssh-key           Update ssh key for the user for ssh authentication
where             show the current mode

apic1(config-username)# exit
```

## Configuring a Local User Using the REST API

### Procedure

Create a local user.

**Example:**

```
URL: https://apic-ip-address/api/node/mo/uni/userext.xml
POST CONTENT:
<aaaUser name="operations" phone="" pwd="<strong_password>" >
  <aaaUserDomain childAction="" descr="" name="all" rn="userdomain-all" status="">
    <aaaUserRole childAction="" descr="" name="Ops" privType="writePriv"/>
  </aaaUserDomain>
</aaaUser>
```

## Generating an X.509 Certificate and a Private Key

**Procedure**

**Step 1** Enter an OpenSSL command to generate an X.509 certificate and private key.

**Example:**

```
$ openssl req -new -newkey rsa:1024 -days 36500 -nodes -x509 -keyout userabc.key -out
userabc.crt -subj '/CN=User ABC/O=Cisco Systems/C=US'
```

**Note**

- Once the X.509 certificate is generated, it will be added to the users profile on the APIC, and it is used to verify signatures. The private key is used by the client to generate the signatures.
- The certificate contains a public key but not the private key. The public key is the primary information used by the APIC to verify the calculated signature. The private key is never stored on the APIC. You must keep it secret.

**Step 2** Display the fields in the certificate using OpenSSL.

**Example:**

```
$ openssl x509 -text -in userabc.crt
Certificate:
  Data:
    Version: 3 (0x2)
    Serial Number:
      c4:27:6c:4d:69:7c:d2:b6
    Signature Algorithm: sha1WithRSAEncryption
    Issuer: CN=User ABC, O=Cisco Systems, C=US
    Validity
      Not Before: Jan 12 16:36:14 2015 GMT
      Not After : Dec 19 16:36:14 2114 GMT
    Subject: CN=User ABC, O=Cisco Systems, C=US
    Subject Public Key Info:
      Public Key Algorithm: rsaEncryption
      RSA Public Key: (1024 bit)
      Modulus (1024 bit):
        00:92:35:12:cd:2b:78:ef:9d:ca:0e:11:77:77:3a:
        99:d3:25:42:94:b5:3e:8a:32:55:ce:e9:21:2a:ff:
        e0:e4:22:58:6d:40:98:b1:0d:42:21:db:cd:44:26:
        50:77:e5:fa:b6:10:57:d1:ec:95:e9:86:d7:3c:99:
        ce:c4:7f:61:1d:3c:9e:ae:d8:88:be:80:a0:4a:90:
        d2:22:e9:1b:25:27:cd:7d:f3:a5:8f:cf:16:a8:e1:
        3a:3f:68:0b:9c:7c:cb:70:b9:c7:3f:e8:db:85:d8:
        98:f6:e3:70:4e:47:e2:59:03:49:01:83:8e:50:4a:
```

```

                    5f:bc:35:d2:b1:07:be:ec:e1
                    Exponent: 65537 (0x10001)
X509v3 extensions:
    X509v3 Subject Key Identifier:
        0B:E4:11:C7:23:46:10:4F:D1:10:4C:C1:58:C2:1E:18:E8:6D:85:34
    X509v3 Authority Key Identifier:
        keyid:0B:E4:11:C7:23:46:10:4F:D1:10:4C:C1:58:C2:1E:18:E8:6D:85:34
        DirName:/CN=User ABC/O=Cisco Systems/C=US
        serial:C4:27:6C:4D:69:7C:D2:B6

    X509v3 Basic Constraints:
        CA:TRUE
Signature Algorithm: sha1WithRSAEncryption
    8f:c4:9f:84:06:30:59:0c:d2:8a:09:96:a2:69:3d:cf:ef:79:
    91:ea:cd:ae:80:16:df:16:31:3b:69:89:f7:5a:24:1f:fd:9f:
    d1:d9:b2:02:41:01:b9:e9:8d:da:a8:4c:1e:e5:9b:3e:1d:65:
    84:ff:e8:ad:55:3e:90:a0:a2:fb:3e:3e:ef:c2:11:3d:1b:e6:
    f4:5e:d2:92:e8:24:61:43:59:ec:ea:d2:bb:c9:9a:7a:04:91:
    8e:91:bb:9d:33:d4:28:b5:13:ce:dc:fe:c3:e5:33:97:5d:37:
    cc:5f:ad:af:5a:aa:f4:a3:a8:50:66:7d:f4:fb:78:72:9d:56:
    91:2c
[snip]

```

## Creating a Local User and Adding a User Certificate Using the GUI

### Procedure

- Step 1** On the menu bar, choose **ADMIN > AAA**.
- Step 2** In the **Navigation** pane, click **Users** and **Local Users** in the **Work** pane.
- Step 3** In the **Work** pane, verify that you in the **Local Users** tab.
- The admin user is present by default
- Step 4** In the **Work** pane, click on task icon drop-down list and select **Create Local User**.
- Step 5** In the **Security** dialog box, choose the desired security domain for the user, and click **Next**.
- Step 6** In the **Roles** dialog box, click the radio buttons to choose the roles for your user, and click **Next**.
- You can provide read-only or read/write privileges.
- Step 7** In the **User Identity** dialog box, perform the following actions:
- In the **Login ID** field, add an ID.
  - In the **Password** field, enter the password.
  - In the **Confirm Password** field, confirm the password.
  - (Optional) For Certificate based authentication, in the **User Certificate Attribute** field, enter the user identity from the authentication certificate.
  - Click **Finish**.
- Step 8** In the **Navigation** pane, click the name of the user that you created. In the **Work** pane, expand the + sign next to your user in the **Security Domains** area.
- The access privileges for your user are displayed.
- Step 9** In the **Work** pane, in the **User Certificates** area, click the user certificates + sign, and in the **Create X509 Certificate** dialog box, perform the following actions:

- a) In the **Name** field, enter a certificate name.
- b) In the **Data** field, enter the user certificate details.
- c) Click **Submit**.

The X509 certificate is created for the local user.

## Creating a Local User and Adding a User Certificate Using the REST API

### Procedure

Create a local user and add a user certificate.

#### Example:

```
method: POST
url: http://apic/api/node/mo/uni/userext/user-userabc.json
payload:
{
  "aaaUser": {
    "attributes": {
      "name": "userabc",
      "firstName": "Adam",
      "lastName": "BC",
      "phone": "408-525-4766",
      "email": "userabc@cisco.com",
    },
    "children": [{
      "aaaUserCert": {
        "attributes": {
          "name": "userabc.crt",
          "data": "-----BEGIN CERTIFICATE-----\nMIICjjCCAfegAwIBAgIJAMQnbE
<snipped content> ==\n-----END CERTIFICATE-----",
        },
        "children": []
      },
    ],
    "aaaUserDomain": {
      "attributes": {
        "name": "all",
      },
      "children": [{
        "aaaUserRole": {
          "attributes": {
            "name": "aaa",
            "privType": "writePriv",
          },
          "children": []
        }
      }, {
        "aaaUserRole": {
          "attributes": {
            "name": "access-admin",
            "privType": "writePriv",
          },
          "children": []
        }
      }, {
        "aaaUserRole": {
          "attributes": {
            "name": "admin",
```



```
}

```

## Creating a Local User Using Python SDK

### Procedure

Create a local user.

#### Example:

```
#!/usr/bin/env python
from cobra.model.pol import Uni as PolUni
from cobra.model.aaa import UserEp as AaaUserEp
from cobra.model.aaa import User as AaaUser
from cobra.model.aaa import UserCert as AaaUserCert
from cobra.model.aaa import UserDomain as AaaUserDomain
from cobra.model.aaa import UserRole as AaaUserRole
from cobra.mit.access import MoDirectory
from cobra.mit.session import LoginSession
from cobra.internal.codec.jsoncodec import toJSONStr

APIC = 'http://10.10.10.1'
username = 'admin'
password = 'p@$w0rd'

session = LoginSession(APIC, username, password)
modir = MoDirectory(session)
modir.login()

def readfile(fileName=None, mode="r"):
    if fileName is None:
        return ""
    fileData = ""
    with open(fileName, mode) as aFile:
        fileData = aFile.read()
    return fileData

# Use a dictionary to define the domain and a list of tuples to define
# our aaaUserRoles (roleName, privType)
# This can further be abstracted by doing a query to get the valid
# roles, that is what the GUI does

userRoles = {'all': [
    ('aaa', 'writePriv'),
    ('access-admin', 'writePriv'),
    ('admin', 'writePriv'),
    ('fabric-admin', 'writePriv'),
    ('nw-svc-admin', 'writePriv'),
    ('ops', 'writePriv'),
    ('read-all', 'writePriv'),
    ('tenant-admin', 'writePriv'),
    ('tenant-ext-admin', 'writePriv'),
    ('vmm-admin', 'writePriv'),
],
}

uni = PolUni('') # '' is the Dn string for topRoot

```



```

aaaUserEp = AaaUserEp(uni)
aaaUser = AaaUser(aaaUserEp, 'userabc', firstName='Adam',
                  email='userabc@cisco.com')

aaaUser.lastName = 'BC'
aaaUser.phone = '555-111-2222'
aaaUserCert = AaaUserCert(aaaUser, 'userabc.crt')
aaaUserCert.data = readFile("/tmp/userabc.crt")
# Now add each aaaUserRole to the aaaUserDomains which are added to the
# aaaUserCert
for domain,roles in userRoles.items():
    aaaUserDomain = AaaUserDomain(aaaUser, domain)
    for roleName, privType in roles:
        aaaUserRole = AaaUserRole(aaaUserDomain, roleName,
                                   privType=privType)
print toJSONStr(aaaUser, prettyPrint=True)

cr = ConfigRequest()
cr.addMo(aaaUser)
modir.commit(cr)
# End of Script to create a user

```

## Using a Private Key to Calculate a Signature

### Before you begin

You must have the following information available:

- HTTP method - GET, POST, DELETE
- REST API URI being requested, including any query options
- For POST requests, the actual payload being sent to the APIC
- The private key used to generate the X.509 certificate for the user
- The distinguished name for the user X.509 certificate on the APIC

### Procedure

**Step 1** Concatenate the HTTP method, REST API URI, and payload together in this order and save them to a file.

This concatenated data must be saved to a file for OpenSSL to calculate the signature. In this example, we use a filename of payload.txt. Remember that the private key is in a file called userabc.key.

#### Example:

GET example:

```
GET http://10.10.10.1/api/class/fvTenant.json?rsp-subtree=children
```

POST example:

```
POST http://10.10.10.1/api/mo/tn-test.json{"fvTenant": {"attributes": {"status": "deleted",
"name": "test"}}
```

**Step 2** Verify that the payload.txt file contains the correct information.

For example, using the GET example shown in the previous step:

```
GET http://10.10.10.1/api/class/fvTenant.json?rsp-subtree=children
```

Your payload.txt file should contain only the following information:

```
GET/api/class/fvTenant.json?rsp-subtree=children
```

**Step 3** Verify that you didn't inadvertently create a new line when you created the payload file.

**Example:**

```
# cat -e payload.txt
```

Determine if there is a \$ symbol at the end of the output, similar to the following:

```
GET/api/class/fvTenant.json?rsp= subtree=children$
```

If so, then that means that a new line was created when you created the payload file. To prevent creating a new line when generating the payload file, use a command similar to the following:

```
echo -n "GET/api/class/fvTenant.json?rsp-subtree=children" >payload.txt
```

**Step 4** Calculate a signature using the private key and the payload file using OpenSSL.

**Example:**

```
openssl dgst -sha256 -sign userabc.key payload.txt > payload_sig.bin
```

The resulting file has the signature printed on multiple lines.

**Step 5** Convert the signature to base64 format:

**Example:**

```
openssl base64 -A -in payload_sig.bin -out payload_sig.base64
```

**Step 6** Strip the signature of the new lines using Bash.

**Example:**

```
$ tr -d '\n' < payload_sig.base64
P+OTqK0CeAZj17+Gute2R1Ww8OGgtzE0wsLlx8fIXX14V79Z17
Ou8IdJH9CB4W6CEvdICXqkv3KaQszCIC0+Bn07o3qF//BsIplZmYChD6gCX3f7q
IcjGX+R6HAqGeK7k97cNhXlWEoobFPe/oaajtPjOu3tdOjhF/9ujG6Jv6Ro=
```

**Note** This is the signature that will be sent to the APIC for this specific request. Other requests will require to have their own signatures calculated.

**Step 7** Place the signature inside a string to enable the APIC to verify the signature against the payload.

This complete signature is sent to the APIC as a cookie in the header of the request.

**Example:**

```
APIC-Request-Signature=P+OTqK0CeAZj17+Gute2R1Ww8OGgtzE0wsLlx8f
IXX14V79Z17Ou8IdJH9CB4W6CEvdICXqkv3KaQszCIC0+Bn07o3qF//BsIplZmYChD6gCX3f
7qIcjGX+R6HAqGeK7k97cNhXlWEoobFPe/oaajtPjOu3tdOjhF/9ujG6Jv6Ro=;
APIC-Certificate-Algorithm=v1.0; APIC-Certificate-Fingerprint=fingerprint;
APIC-Certificate-DN=uni/userext/user-userabc/usercert-userabc.crt
```

**Note** The DN used here must match the DN of the user certified object containing the x509 certificate in the next step.

**Step 8** Use the CertSession class in the Python SDK to communicate with an APIC using signatures.

The following script is an example of how to use the CertSession class in the ACI Python SDK to make requests to an APIC using signatures.

**Example:**

```
#!/usr/bin/env python
# It is assumed the user has the X.509 certificate already added to
# their local user configuration on the APIC
from cobra.mit.session import CertSession
from cobra.mit.access import MoDirectory

def readFile(fileName=None, mode="r"):
    if fileName is None:
        return ""
    fileData = ""
    with open(fileName, mode) as aFile:
        fileData = aFile.read()
    return fileData

pkey = readFile("/tmp/userabc.key")
csession = CertSession("https://ApicIPorHostname/",
                       "uni/userext/user-userabc/usercert-userabc", pkey)

modir = MoDirectory(csession)
resp = modir.lookupByDn('uni/fabric')
print resp.dn
# End of script
```

**Note** The DN used in the earlier step must match the DN of the user certified object containing the x509 certificate in this step.

---

## Configuring User Lockout After Continuous Failed Attempts to Log in using the GUI

You can block a user from being able to log in after the user fails a configured number of login attempts. You can specify how many failed login attempts the user can have within a specific time period. If the user fails to log in too many times, then that user becomes unable to log in for a specified period of time.

### Procedure

---

- Step 1** On the menu bar, choose **Admin > AAA**.
- Step 2** In the **Navigation** pane, choose **Security**.
- Step 3** In the **Work** pane, choose the **Management Settings > Policy** tab, if it is not chosen already.
- Step 4** Under **Properties**, fill out the fields as follows:
  - a) For **Lockout User after multiple failed login attempts**, choose **Enable**.
  - b) For **Number of failed attempts before user is locked out**, enter the desired value.

The range is from 1 to 15. The default is 5.

- c) For **Time period in which consecutive attempts were failed (m)**, enter a value in minutes for the time interval during which the Cisco Application Policy Infrastructure Controller (APIC) will count the failed attempts.

The range is from 1 to 720. The default is 5.

- d) For **Duration of lockout (m)**, enter a value in minutes for how long a user will be locked out for failing to log in too many times.

**Step 5** Click **Submit**.

---

## Configuring a Local User for OTP-Based Two-Factor Authentication Using the GUI

The following procedure configures OTP-based two-factor authentication for a local user using the Cisco APIC GUI. The procedure assumes that you are a fabric administrator.

### Before you begin

You must have already created a local user for which you want to enable OTP-based two-factor authentication.

### Procedure

---

**Step 1** On the menu bar, choose **Admin > AAA**.

**Step 2** In the **Navigation** pane, choose **Users**.

**Step 3** Double-click the user for which you want to enable OTP-based two-factor authentication.

**Step 4** For **Enable OTP**, choose **Yes**.

**Step 5** Click **Submit**.

**Step 6** In the **Policy Usage Warning** dialog, click **Submit Changes**.

From this point, you can provide the QR code or OTP key to the user such as through an email, or the user can log into the Cisco APIC GUI to get the code and key directly.

**Step 7** (Optional) If you want to provide the QR code or OTP key to the user, continue with the substeps. Otherwise, stop here.

- a) Double-click the user again.
- b) To the right of **OTP Key**, click the expand button.

A dialog displays that includes the QR code and OTP key.

- c) Provide the QR code or OTP key to the user.
  - d) In the Cisco APIC, click **Close**.
  - e) Click **Close**.
-

**What to do next**

The user for which you enabled OTP must complete the configuration of OTP authentication. See [Completing the Configuration of OTP-Based Two-Factor Authentication by a User Using the GUI](#), on page 41.

**Completing the Configuration of OTP-Based Two-Factor Authentication by a User Using the GUI**

The following procedure completes the configuration of OTP-based two-factor authentication using the Cisco APIC GUI. The procedure assumes that you are a user for which a fabric administrator enabled OTP-based two-factor authentication.

**Before you begin**

A fabric administrator must have enabled OTP-based two-factor authentication for your account.

**Procedure**

- 
- Step 1** On your Android or Apple iOS smartphone, download the appropriate two-factor authentication app.
  - Step 2** Get the QR code or OTP key from the fabric administrator or by logging in to the Cisco APIC GUI.  
If you log into the GUI, the QR code and OTP key display after you enter your credentials.
  - Step 3** Using your smartphone, scan the QR code and follow the two-factor authentication app's directions, or enter the OTP key in the Cisco APIC GUI.
- 

## Recovering Cisco APIC Passwords and Accessing Special Logins

### Recovering the APIC Password

Follow these steps to recover the APIC password.

**Procedure**

- 
- Step 1** Create and save an empty file named "aci-admin-passwd-reset.txt".
  - Step 2** Add the file to a USB drive. You can format the USB drive to FAT or FAT32.
  - Step 3** Connect the USB drive to one of the rear USB ports on the Cisco APIC.
  - Step 4** Reboot the Cisco APIC using Cisco Integrated Management Controller (CIMC) or by hard power cycling the device.
  - Step 5** Press the **Esc** key during the 10-second countdown timer that appears at the top left to bring up the list of boot targets.
  - Step 6** Press the **e** key to edit the default grub line.

- Step 7** Go to the line that begins with "linux." Using the **End** key or **Right Arrow** key, move the cursor to the end of that line and append "aci-admin-passwd-reset".
- Step 8** Press **Ctrl+X** to boot the entry.
- It may take a few minutes for the new password to take effect.

## Using the Rescue-user Account to Erase the Cisco APIC Configuration Using the NX-OS Style CLI

The rescue-user is an emergency login that provides access to the Cisco APIC even when it is not in a cluster. You can use this login to run troubleshooting commands including erasing the configuration.



**Note** For a standby Cisco APIC, you can log in using SSH with the username "rescue-user" and no password. If the standby Cisco APIC was previously part of a fabric, the "rescue-user" account will retain the old administrator password, unless the operating system is re-installed using the keyboard, video, mouse (KVM) console.

### Procedure

**Step 1** Access the APIC using the Cisco Integrated Management Controller (CIMC) console.

**Step 2** Login as rescue-user.

**Note** If an admin password is in place and the Cisco APIC is logged onto the fabric, the rescue-user password is the same as the admin password. Otherwise there is no rescue-user password.

**Step 3** Use the **acidiag touch** command to clear the configuration.

#### Example:

```
apic1# acidiag touch setup
```

## Using the Fallback Login Domain to Log in to the Local Database

There is a hidden login domain named "fallback" that allows you to log in using the local user database in case of lockout. The format of the username used for the authentication method is `apic#fallback\<username>`.

### Procedure

**Step 1** Use the fallback login domain to log in to the local database in the GUI or log in to the fallback login domain using the NX-OS-style CLI, shown as follows:

```
apic1(config)# aaa authentication login domain fallback
apic1(config-domain)# ?
group Set provider group for login domain
realm Specify server realm
```

**Step 2** Optionally, you can instead use the REST API to log in to the fallback login domain, shown as follows:

- URL: `https://ip_address/api/aaaLogin.xml`

- DATA:

```
<aaaUser name="apic#fallback\admin"
pwd="passwordhere"/>
```

---







## CHAPTER 4

# Restricting Access Using Security Domains and Node Rules

---

- [Restricting Access by Domains, on page 45](#)
- [Assigning a Node to a Domain, on page 46](#)
- [Guidelines and Limitations for Security Domains and Node Rules, on page 46](#)
- [Creating a Security Domain, on page 47](#)
- [Creating a Node Rule to Assign Access to a Node, on page 47](#)
- [Configuring a User with a Security Domain, on page 48](#)
- [Custom Roles and Privileges, on page 49](#)
- [Use Case Example of Configuring an RBAC Node Rule, on page 51](#)

## Restricting Access by Domains

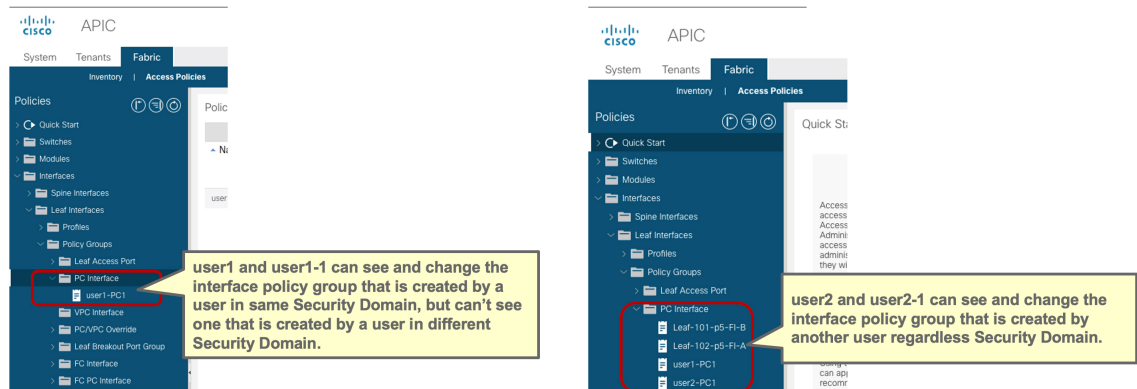
Security domains allow fabric administrators to expose resources selectively to a set of users and provide those users with the required level of permissions to read and modify those resources. By using security domains, multiple set of users can share the underlying infrastructure while having separated management access to their resources.

Starting with Cisco Application Policy Infrastructure Controller (APIC) release 5.0(1), you can configure security domains as "Restricted." A restricted security domain allows a fabric administrator to prevent a group of users from viewing or modifying any objects created by a group of users associated with a different security domain when users in both groups have the same assigned privileges.

For example, a user associated with restricted security domain `domainA` cannot see policies, profiles, or users configured by users associated with security domain `domainB`. Users associated with `domainB` can see policies, profiles, or users configured by users associated with `domainA`, unless `domainB` is also configured as restricted. A user will always have read-only visibility to system-created configurations for which the user has proper privileges. You can give a user associated with a restricted security domain a broad level of privileges within that domain without the concern that the user could inadvertently affect another tenant's physical environment.

The following figure illustrates the concept of restricted security domains:

Figure 5: Restricted Security Domains



Restricted security domains play an important role in providing multi-tenancy capabilities in policies and profiles outside the tenant level, such as in access policies. Even if access policies do not belong to any tenant, by using separated restricted security domains per tenant, users from each tenant can create access policies that are hidden to users in other tenants.

## Assigning a Node to a Domain

Using an RBAC node rule, the fabric administrator can assign a physical node, such as a leaf switch, to a security domain. This node assignment allows a user in that security domain to access and perform operations on a node assigned as part of the node rule. Only a user with node management privileges within the security domain can configure nodes assigned to that domain. The user has no access to nodes outside of the security domain, and users in other security domains have no access to the node assigned to the security domain. To create or modify configurations on a node assigned to the security domain, a user in that domain must also be assigned to domain `all` with the `port-mgmt` role that contains the `custom-port-privilege` privilege by default or a custom role that contains the `custom-port-privilege` privilege.



**Note** When configuring a local user who will manage ports on an assigned node, you must grant the user a role in domain `all`, and the `admin` role in the security domain to which the node is assigned. Both roles must have the **Role Privilege Type** configured as `Write`.

## Guidelines and Limitations for Security Domains and Node Rules

When configuring security domains and node rules, follow these guidelines and limitations. In this section, a "restricted node user" is a user in a restricted security domain to which a node has been assigned.

- When upgrading from an earlier Cisco Application Policy Infrastructure Controller (APIC) release to a 5.0 release, you must reconfigure any rules, policies, or roles that use the more granular earlier privileges.
- When downgrading from a Cisco APIC 5.0 release to an earlier release, you must manually edit and retain default roles. Roles modified under a Cisco APIC 5.0 release are retained.
- A spine switch cannot be assigned using RBAC node rules.

- When creating RBAC node rules, you should not assign a node to more than one security domain.
- A restricted node user can configure only policies. An admin user should perform node configuration and troubleshooting.
- A restricted node user can access default system-created managed objects.
- A restricted node user can view fabric-level fault counts in the Fault Dashboard.
- A restricted node user can view node-level faults, such as those from AAA servers, NTP servers, and DNS servers.
- If an admin or nonrestricted domain user associates a relationship policy to an access policy created by a restricted node user, that policy will be visible to the restricted node user.
- You cannot configure a restricted node user using the CLI.
- By default, the `port-mgmt` role has the `custom-port-privilege` privilege that contains predefined access policy managed objects. You can add more managed objects using the procedure in [Configuring a Custom Privilege, on page 50](#).

## Creating a Security Domain

Use this procedure to create a security domain.

### Procedure

---

- Step 1** On the menu bar, choose **Admin > AAA**.
- Step 2** In the **Navigation** pane, click **Security**.
- Step 3** In the **Work** pane, select the **Security Domains** tab.
- Step 4** In the **Work** pane, click on the Actions icon drop-down list and select **Create Security Domain**.
- Step 5** In the **Create Security Domain** dialog box, perform the following actions:
- a) In the **Name** field, type a name for the security domain.
  - b) (Optional) Set the **Restricted Domain** control to **No** (the default) or **Yes**.  
If you configured the security domain as a restricted domain, users who are assigned to this domain cannot see policies, profiles, or users configured by users associated with other security domains.
  - c) Click **Submit**.
- 

## Creating a Node Rule to Assign Access to a Node

Use this procedure to configure an RBAC node rule that assigns a physical node, such as a leaf switch, to a security domain.

**Before you begin**

Create a security domain to which the node will be assigned.

**Procedure**


---

**Step 1** On the menu bar, choose **Admin > AAA**.

**Step 2** In the **Navigation** pane, click **Security**.

**Step 3** In the **Work** pane, select the **RBAC Rules** tab and the **Node Rules** subtab.

**Step 4** In the **Work** pane, click the Actions icon drop-down list and select **Create RBAC Node Rule**.

**Step 5** From the **Node ID** drop-down list, select the node to be assigned.

**Tip** The **Node ID** drop-down list contains additional drop-down lists for sorting the nodes by ID, name, or type.

**Step 6** In the **Port Rules** taskbar, click the + icon and perform the following actions:

- a) Type a **Name** for the RBAC node rule.
  - b) From the **Domain** drop-down list, select the security domain to which the node will be assigned.
  - c) Click **Update**.
  - d) Click **Submit**.
- 

**What to do next**

Assign users who will manage the node assigned to the security domain.

## Configuring a User with a Security Domain

Use this procedure to add a local user as an `admin` in a security domain.




---

**Tip** This procedure shows the minimum steps for this task, omitting detailed information and optional steps. For a more detailed general procedure for adding a new local user, see [Configuring a Local User Using the GUI, on page 29](#).

---

**Before you begin**

The security domain(s) that the user will access are defined.

**Procedure**


---

**Step 1** On the menu bar, choose **Admin > AAA**.

**Step 2** In the **Navigation** pane, click **Users**.

In the **Work** pane, verify that you are in the **Local Users** tab.

- Step 3** In the **Work** pane, click the Actions icon drop-down list and select **Create Local User**.
- Step 4** In the **STEP 1 > User Identity** dialog box, perform the following actions:
- In the **Login ID** field, add a user ID.
  - In the **Password** fields, enter and confirm a password for the user.
  - Click **Next**.
- Step 5** In the **STEP 2 > Security** dialog box, under **Security Domain**, check the boxes for the domain 'all' and for the security domain that has the associated RBAC node rule, then click **Next**.
- Step 6** In the **STEP 3 > Roles** dialog box, perform the following actions:
- In the taskbar for the domain 'all,' click the + icon to assign a role for the user in that domain.
  - From the **Role Name** drop-down list, choose 'port-mgmt' and configure the **Role Privilege Type** as 'write.'
  - Click **Update**.
  - In the taskbar for the security domain, click the + icon to assign a role for the user in that domain.
  - From the **Role Name** drop-down list, choose 'admin' and configure the **Role Privilege Type** as 'write.'
  - Click **Update**.
- Step 7** Click **Finish**.
- 

## Custom Roles and Privileges

### Creating a Custom Role with Custom Privileges

Use this procedure to create a role and choose a set of privileges.

#### Before you begin

Refer to the set of predefined roles and privileges listed in [AAA RBAC Roles and Privileges, on page 8](#) to determine which privileges should be available in the custom role. If you need read or write access to a managed object (MO) that is not exposed in a predefined privilege, you can configure a custom privilege, as described in [Configuring a Custom Privilege, on page 50](#).

#### Procedure

---

- Step 1** On the menu bar, choose **Admin > AAA**.
- Step 2** In the **Navigation** pane, click **Security**.
- Step 3** In the **Work** pane, select the **Roles** tab.
- Step 4** In the **Work** pane, click on the Actions icon drop-down list and select **Create Role**.
- Step 5** In the **Create Role** dialog box, perform the following actions:
- In the **Name** field, type a name for the role.
  - From the **Privileges** table, check the box or boxes of the desired privileges for this role.
  - Click **Submit**.
-

**What to do next**

If you selected a custom privilege, such as `custom-privilege-1`, follow the steps in [Configuring a Custom Privilege, on page 50](#) to choose the managed objects (MOs) that will be exposed with this custom privilege.

## Configuring a Custom Privilege

Use this procedure to configure a custom privilege, providing read or read/write access to one or more managed objects (MOs) that are not exposed in a predefined privilege.

Managed object classes are described in the [Cisco APIC Management Information Model Reference](#). For each MO class, the reference lists the predefined roles that have read or read/write privileges for that class.

For each predefined privilege, you can see a list of MO classes and the read/write permission by using the [Cisco APIC Roles and Privileges Matrix](#).

To configure a custom privilege with read or write access permission to an MO class, you must use the APIC REST API. For instructions on using the API, see the *Cisco APIC REST API Configuration Guide*.

**Procedure**


---

Compose and send an APIC REST API POST in the format below to create an object of class `aaa:RbacClassPriv`.

**Example:**

```
POST https://<APIC-IP>/api/node/mo/uni/rbacdb/rbacclpriv-<moClassName>.json

{
  "aaaRbacClassPriv":
  {
    "attributes":
    {
      "name": "<moClassName>",
      "wPriv": "<privilege>",
      "rPriv": "<privilege>"
    }
  }
}
```

In the `moClassName` value of the URI, include the name of the object class for which you are configuring access.

In the payload, provide the following attributes:

- `name`: Name of the object class for which you are configuring access.
- `wPriv`: Name of the custom privilege that will include write access to objects of the class.
- `rPriv`: Name of the custom privilege that will include read access to objects of the class.

To assign read and write access to a custom privilege, enter the name of the custom privilege in both `wPriv` and `rPriv`.

---

### Example

This example shows how to configure the custom privilege `custom-privilege-1` with both read and write access to objects of the class `fabric:Pod`.

```
POST https://apic-aci.cisco.com/api/node/mo/uni/rbacdb/rbacclpriv-fabricPod.json
```

```
{
  "aaaRbacClassPriv":
  {
    "attributes":
    {
      "name": "fabricPod",
      "wPriv": "custom-privilege-1",
      "rPriv": "custom-privilege-1"
    }
  }
}
```

### What to do next

Add the custom privilege to a custom role, using the procedure described in [Creating a Custom Role with Custom Privileges, on page 49](#).

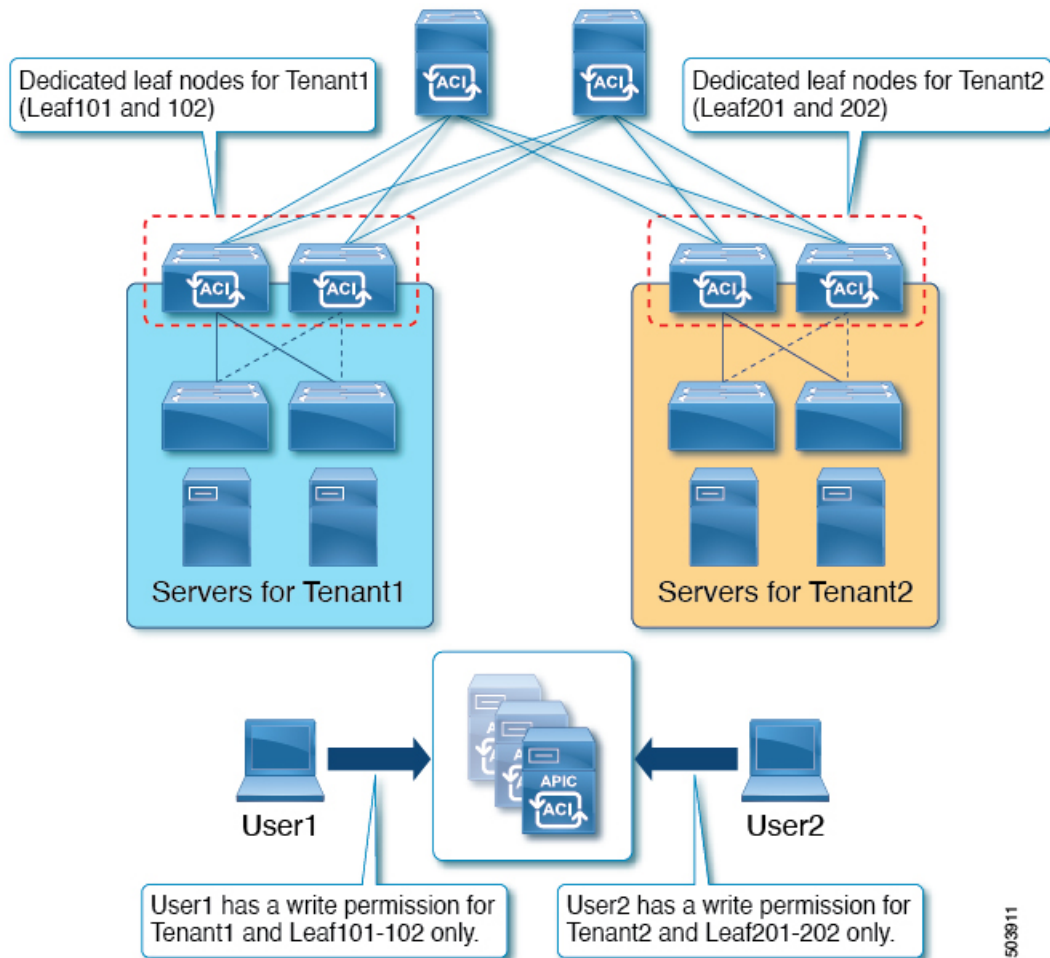
## Use Case Example of Configuring an RBAC Node Rule

This section explains a use case that has a mix of configuration options described in this document. See the other parts of this document for information about each option. The use case is based on the following scenario:

Imagine that you have multiple tenants and multiple leaf nodes in your Cisco Application Centric Infrastructure (ACI) fabric. For multi-tenancy, you want to allow a user to manage a specific tenant and a specific set of leaf nodes only. For example:

- User1 can manage only Tenant1, leaf node 101 and 102.
- User2 can manage only Tenant2, leaf node 201 and 202.

The following figure illustrates the requirements:

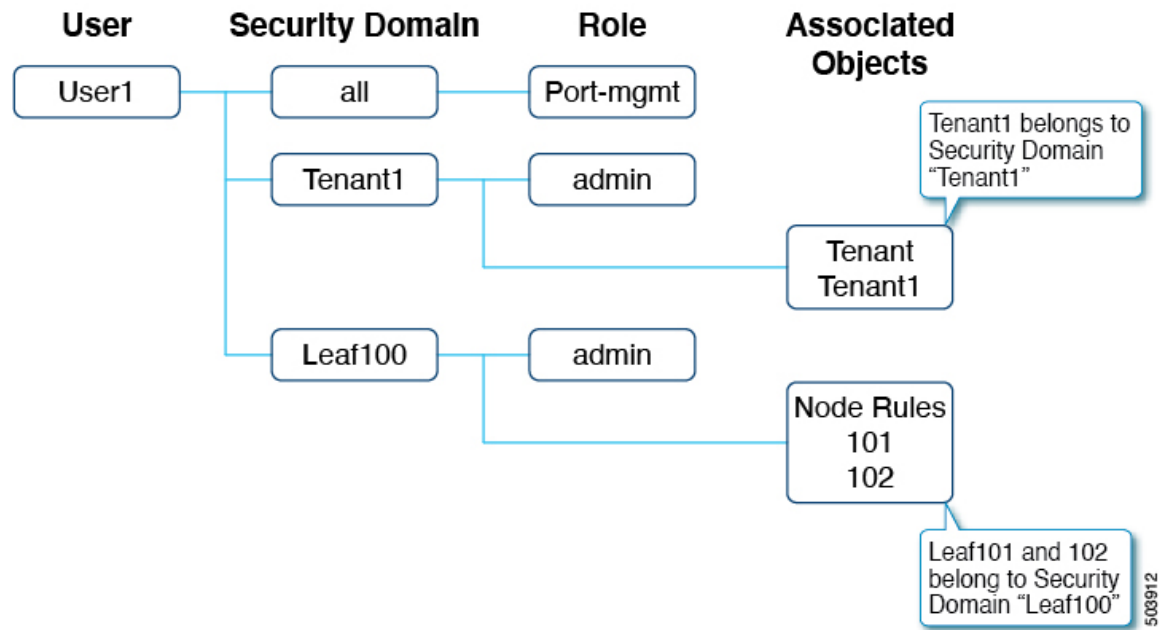


This can be achieved by using security domains and RBAC node rules. At a high level, the configuration steps are as follows:

1. Create security domains
2. Create RBAC node rules
3. Create users

The following figure illustrates the relationship between the configurations for User1 in this example:

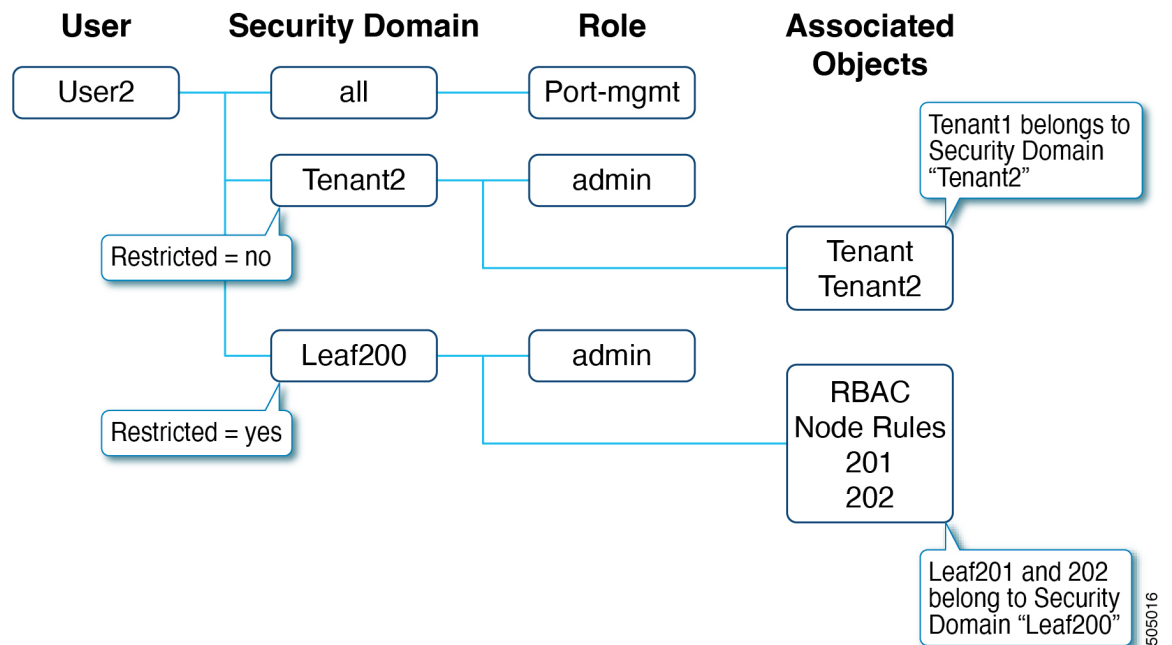




User1 has three security domains:

- Domain `all` with `port-mgmt` role: Enables User1 to manage ports related configuration on the assigned leaf nodes.
- Domain `Tenant1` with `admin` role: Enables User1 to manage Tenant1.
- Domain `Leaf100` with `admin` role: Enables User1 to manage Leaf101 and 102.

The following figure illustrates the relationship between the configurations for User2 in this example:



User2 has three security domains as well:

- Domain `all` with `port-mgmt` role: Enables User2 to manage ports related configuration on the assigned leaf nodes.
- Domain `Tenant2` with `admin` role: Enables User2 to manage Tenant2.
- Domain `Leaf200` with `admin` role: Enables User2 to manage Leaf201 and 202.

The following subsections explain the configuration steps in greater detail. The sections describe only the configurations for User1 and Tenant1. The configurations for User2 and Tenant2 follow the same process.

### Step 1: Create Security Domains

The first step is to create the security domains: Tenant1 and Leaf100. Although you can combine these security domains, this example uses separate security domains.

To create the domains, in the GUI, go to **Admin > AAA > Security > Security Domains > Create Security Domain**.

The screenshot shows the Cisco APIC GUI. The 'Admin' tab is selected, and the 'Security Domains' sub-tab is active. A table lists existing security domains: ACI-SCVMM, ACI-vDS, all, common, and mgmt. A 'Create Security Domain' button is highlighted. A blue arrow points to a modal window for creating a new security domain named 'Leaf100'. In this modal, the 'Restricted Domain' toggle is set to 'Yes' and is highlighted with a red box. Below the modal, another modal for 'Tenant1' is shown with 'Restricted Domain' set to 'No'. At the bottom right, 'Cancel' and 'Submit' buttons are visible.

In this example, **Restricted Domain** is set to **Yes** for security domain Leaf100, which prevents that User1 from seeing the interface policy group, VLAN pool, and other access policies created by other users in different security domains. Exceptions are the default interface policies. Regardless of the **Restricted Domain** configuration, default interface policies are visible to the leaf RBAC user. That said, if **Restricted Domain** is enabled, the user cannot make a change to the configuration of the default policies.

The **Restricted Domain** is not enabled for security domain Tenant1. For tenant policies, the tenant itself provides enough management isolation, hence it is not required. If you use the same security domain for both tenant RBAC and node RBAC, then enabling the **Restricted Domain** may be required.

For the tenant RBAC, a tenant must be associated to a security domain. This example associates Tenant1 to security domain "Tenant1." To associate the domains, in the GUI, go to **Tenant > Policy > Security Domains**.

The image consists of two screenshots from the Cisco APIC GUI. The top screenshot shows the 'User Management - Security' page with the 'Security Domains' tab selected. A table lists several security domains, with 'Tenant1' highlighted by a red box. The bottom screenshot shows the 'Tenant - Tenant1' configuration page with the 'Policy' tab selected. A red box highlights the 'Security Domains' field, which contains a table with 'Tenant1' listed. A yellow callout box with a speech bubble points to this field, containing the text: 'Associate to Tenant1 with Security Domain "Tenant1".'

### Step 2: Create RBAC Node Rules

The next step is to create RBAC node rules to add Leaf101 and Leaf102 to security domain Leaf100. To create the RBAC node rules, in the GUI, go to **Admin > AAA > Security > RBAC Rules > Node Rules > Create RBAC Node Rule**.

The following figure shows the RBAC rule for node 101:

The screenshot displays the Cisco APIC GUI. The top navigation bar includes 'System', 'Tenants', 'Fabric', 'Virtual Networking', 'Admin', 'Operations', 'Apps', and 'Integrations'. The 'Admin' tab is selected, and the 'AAA' sub-tab is active in the left sidebar. The 'Security' sub-tab is also selected. The main content area shows 'User Management - Security' with tabs for 'Management Settings', 'Security Domains', 'Roles', 'RBAC Rules', and 'Public Key Management'. The 'RBAC Rules' tab is active, and the 'Node Rules' sub-tab is selected. A 'Create RBAC Node Rule' button is highlighted. A blue arrow points to a modal window titled 'Create RBAC Node Rule' where 'Node ID' is set to 101 and a port rule is defined with 'Name' 101 and 'Domain' Leaf100. A second modal window shows the same configuration for 'Node ID' 102.

Repeat the same configuration for node 102.

### Step 3: Create Users

The last step is to create a user: User1. To create the user, in the GUI, go to **Admin > AAA > Users > Create Local User**.

At the **Security** and **Roles** configuration steps, choose the following security domains and roles:

## Use Case Example of Configuring an RBAC Node Rule

- all: Role `port-mgmt` with the `Write` privilege
- Leaf100: Role `admin` with the `Write` privilege
- Tenant1: Role `admin` with the `Write` privilege

You can use the same configuration for remote users, using either Cisco AVPairs or LDAP group maps, using the procedure described in the "RADIUS, TACACS+, LDAP, RSA, SAML, OAuth 2, and DUO" chapter.

The screenshot shows the Cisco APIC Admin console. The 'Admin' tab is selected. The 'Users' page is displayed, with the 'Local Users' section highlighted. The 'Create Local User' button is visible. A blue arrow points from the 'Create Local User' button to the 'Create Local User' form. The form shows three domains: 'all', 'Leaf100', and 'Tenant1'. Each domain has a table with columns 'Role Name' and 'Role Privilege Type'. For 'all', the role is 'port-mgmt' with 'Write' privilege. For 'Leaf100' and 'Tenant1', the role is 'admin' with 'Write' privilege.

### Verifying the RBAC Node Rule

User1 can manage only Tenant1, Leaf 101 and 102. For example:

- User1 cannot see other tenants other than Tenant1 with write privilege and the common tenant with read privilege.

- User1 cannot see other leaf nodes other than Leaf101 and 102 in **Leaf Selectors**.
- User1 cannot see access policies other than those created by users associated with the same security domain, or system-created policies (read-only).

APIC

System **Tenants** Fabric Virtual Networking Operations Apps Integrations

ALL TENANTS | Add Tenant | Tenant Search: name or descr | common | Tenant1

All Tenants

Name	Alias	Description	Bridge Domains
common	common	Tenant Created Using Ansible	1
Tenant1	Tenant1		0

APIC

System Tenants **Fabric** Virtual Networking Operations Apps Integrations

Inventory | Access Policies

Policies

Leaf Switches - Profiles

Create Leaf Profile

STEP 1 > Profile

1. Profile 2. Associations

Name:

Description: optional

Leaf Selectors:

Name	Blocks	Policy Group
<input type="text"/>	select switches	select an option

ID	Name	Profiles
101	Pod1-Leaf1	
102	Pod1-Leaf2	







## CHAPTER 5

# TACACS+, RADIUS, LDAP, RSA, SAML, and DUO

This chapter contains the following sections:

- [Overview](#), on page 61
- [RADIUS](#), on page 62
- [TACACS+ Authentication](#), on page 62
- [User IDs in the APIC Bash Shell](#), on page 63
- [Login Domains](#), on page 63
- [Creating Login Domain Using the GUI](#), on page 64
- [LDAP/Active Directory Authentication](#), on page 65
- [RSA Secure ID Authentication](#), on page 65
- [DUO Two Factor Authentication](#), on page 65
- [Configuring DUO RADIUS Proxy Provider](#), on page 66
- [Configuring DUO LDAP Proxy Provider](#), on page 67
- [Configuring DUO Proxy Using the REST API](#), on page 68
- [Configuring APIC for RSA Access Using the GUI](#), on page 70
- [Configuring a Remote User](#), on page 71
- [About SAML](#), on page 82

## Overview

This article provides step by step instructions on how to enable RADIUS, TACACS+, and LDAP users to access the APIC. It assumes the reader is thoroughly familiar with the *Cisco Application Centric Infrastructure Fundamentals* manual, especially the User Access, Authentication, and Accounting chapter.



---

**Note** In the case of a disaster scenario such as the loss of all but one APIC in the cluster, APIC disables remote authentication. In this scenario, only a local administrator account can log into the fabric devices.

---



---

**Note** Remote users for AAA Authentication with shell:domains=all/read-all/ will not be able to access Leaf switches and Spine switches in the fabric for security purposes. This pertains to all version up to 4.0(1h).

---

# RADIUS

To configure users on RADIUS servers, the APIC administrator must configure the required attributes (`shell:domains`) using the `cisco-av-pair` attribute. The default user role is `network-operator`.

The SNMPv3 authentication protocol options are SHA and MD5. The privacy protocol options are AES-128 and DES. If these options are not specified in the `cisco-av-pair` attribute, MD5 and DES are the default authentication protocols.

For example, SNMPv3 authentication and privacy protocol attributes can be specified as follows:

```
snmpv3:auth=SHA priv=AES-128
```

Similarly, the list of domains would be as follows:

```
shell:domains="domainA domainB ..."
```

## TACACS+ Authentication

Terminal Access Controller Access Control System Plus (TACACS+) is another remote AAA protocol that is supported by Cisco devices. TACACS+ has the following advantages over RADIUS authentication:

- Provides independent AAA facilities. For example, the Cisco Application Policy Infrastructure Controller (APIC) can authorize access without authenticating.
- Uses TCP to send data between the AAA client and server, enabling reliable transfers with a connection-oriented protocol.
- Encrypts the entire protocol payload between the switch and the AAA server to ensure higher data confidentiality. RADIUS encrypts passwords only.
- Uses the `av-pairs` that are syntactically and configurationally different than RADIUS but the Cisco APIC supports `shell:domains`.

The following XML example configures the Cisco Application Centric Infrastructure (ACI) fabric to work with a TACACS+ provider at IP address 10.193.208.9:

```
<aaaTacacsPlusProvider name="10.193.208.9"
  key="test123"
  authProtocol="pap"/>
```




---

**Note** While the examples provided here use IPv4 addresses, IPv6 addresses could also be used.

---

The following guidelines and limitations apply when using TACACS+:

- The TACACS server and TACACS ports must be reachable by ping.
- The TACACS server with the highest priority is considered first to be the primary server.

## User IDs in the APIC Bash Shell

User IDs on the APIC for the Linux shell are generated within the APIC for local users. Users whose authentication credential is managed on external servers, the user ID for the Linux shell can be specified in the `cisco-av-pair`. Omitting the (16001) in the above `cisco-av-pair` is legal, in which case the remote user gets a default Linux user ID of 23999. Linux User IDs are used during bash sessions, allowing standard Linux permissions enforcement. Also, all managed objects created by a user are marked as created-by that user's Linux user ID.

The following is an example of a user ID as seen in the APIC Bash shell:

```
admin@ifav17-ifc1:~> touch myfile
admin@ifav17-ifc1:~> ls -l myfile
-rw-rw-r-- 1 admin admin 0 Apr 13 21:43 myfile
admin@ifav17-ifc1:~> ls -ln myfile
-rw-rw-r-- 1 15374 15374 0 Apr 13 21:43 myfile
admin@ifav17-ifc1:~> id
uid=15374(admin) gid=15374(admin) groups=15374(admin)
```

## Login Domains

A login domain defines the authentication domain for a user. Login domains can be set to the Local, LDAP, RADIUS, or TACACS+ authentication mechanisms. When accessing the system from REST, the CLI, or the GUI, the APIC enables the user to select the correct authentication domain.

For example, in the REST scenario, the username is prefixed with a string so that the full login username looks as follows:

```
apic:<domain>\<username>
```

If accessing the system from the GUI, the APIC offers a drop-down list of domains for the user to select. If no `apic: domain` is specified, the default authentication domain servers are used to look up the username.

Starting in ACI version 1.0(2x), the login domain fallback of the APIC defaults local. If the default authentication is set to a non-local method and the console authentication method is also set to a non-local method and both non-local methods do not automatically fall back to local authentication, the APIC can still be accessed via local authentication.

To access the APIC fallback local authentication, use the following strings:

- From the GUI, use `apic:fallback\username`.
- From the REST API, use `apic#fallback\username`.



---

**Note** Do not change the fallback login domain. Doing so could result in being locked out of the system.

---

# Creating Login Domain Using the GUI

## Before you begin

- The ACI fabric is installed, Application Policy Infrastructure Controllers (APICs) are online, and the APIC cluster is formed and healthy.
- The login domain name, realm, and remote server provider group are available to define the authentication domain for the user.

## Procedure

---

### Step 1

In the APIC, create Login Domain.

- a) On the menu bar, choose **Admin** > **AAA**.
- b) In the **Navigation** pane, click **Authentication** and then click the **Policy** tab.
- c) In the **Properties** pane, click + to create a Login Domain.
- d) In the **Create Login Domain** pane, specify the following:
  - The user configured domain name.
  - Description of the login domain.
  - The realm to verify the identity of an entity (person or device) accessing the fabric devices.
    1. For Release 4.2(x) and earlier, choose a security method from Local, LDAP, RADIUS, TACACS+, RSA, or SAML for processing authentication requests.
    2. For Release 5.0(x) and later, choose a security method from DUO Proxy LDAP, DUO Proxy Radius, LDAP, RADIUS, TACACS+, RSA, SAML, or Local for processing authentication requests.

**Note** If LDAP, RADIUS, or TACACS+ is specified as the default security method and the associated provider group specified in this dialog is not available to provide authentication during a user login, fallback local authentication is not executed by the APIC server unless is specifically configured to do so.

- A RADIUS provider group for a group of remote servers supporting the RADIUS protocol for authentication.
- A TACACS+ provider group for a group of remote servers supporting the TACACS+ protocol for authentication.
- An LDAP provider group for a group of remote servers supporting the LDAP protocol for authentication.
- A RSA provider group for a group of remote servers supporting the RSA protocol for authentication.
- A SAML provider group for a group of remote servers supporting the SAML protocol for authentication.

**Step 2** Click **Submit**.

---

## LDAP/Active Directory Authentication

Similar to RADIUS and TACACS+, LDAP allows a network element to retrieve AAA credentials that can be used to authenticate and then authorize the user to perform certain actions. An added certificate authority configuration can be performed by an administrator to enable LDAPS (LDAP over SSL) trust and prevent man-in-the-middle attacks.

The XML example below configures the ACI fabric to work with an LDAP provider at IP address 10.30.12.128.



**Note** While the examples provided here use IPv4 addresses, IPv6 addresses could also be used.

---

```
<aaaLdapProvider name="10.30.12.128"
  rootdn="CN=Manager,DC=ifc,DC=com"
  basedn="DC=ifc,DC=com"
  SSLValidationLevel="strict"
  attribute="CiscoAVPair"
  enableSSL="yes"
  filter="cn=$userid"
  port="636" />
```



**Note** For LDAP configurations, best practice is to use **CiscoAVPair** as the attribute string. If customer faces the issue using Object ID 1.3.6.1.4.1.9.22.1, an additional Object ID 1.3.6.1.4.1.9.2742.1-5 can also be used in the LDAP server.

Instead of configuring the Cisco AVPair, you have the option to create LDAP group maps in the APIC.

---

## RSA Secure ID Authentication

RSA Authentication provides a token which can be used in combination with a fixed key in many different ways to create the password. It supports both hardware and software tokens.

## DUO Two Factor Authentication

Cisco APIC supports multi-factor authentication with Duo security. Duo security itself does not act as repository for user identities. It offers second factor (2F) authentication on top of an organization's existing authentication, which could be on-premises or cloud-based. Second factor authentication with Duo occurs once the user has finished the authentication with the organization's primary authentication source.

Duo supports three types of 2F authentication methods after you complete authentication with the primary authentication source:

- Notification push on mobile using the Duo mobile app on smartphones.

- Phone call on your registered phone or mobile numbers.
- Passcode that is generated on the Duo mobile app.

The user is authenticated using the following servers:

- The Duo proxy RADIUS server uses the multi-factor authentication in Cisco APIC to authenticate a distributed client/server system using RADIUS PAP primary authentication method.
- The Duo proxy LDAP server uses the multi-factor authentication in Cisco APIC to authenticate a remote server using Cisco AVPair or Group Maps authentication method.

## Configuring DUO RADIUS Proxy Provider

DUO RADIUS Proxy acts as a proxy RADIUS server that forwards the incoming RADIUS authentication request to the external RADIUS server, waits for response from that server and then if the authentication is successful with the external RADIUS server, it initiates the second factor authentication on the user's secondary device.

### Before you begin

- The ACI fabric is installed, Application Policy Infrastructure Controllers (APICs) are online, and the APIC cluster is formed and healthy.

### Procedure

#### Step 1

In the APIC, configure the DUO RADIUS proxy provider.

- On the menu bar, choose **Admin > AAA**.
- In the **Navigation** pane, click **Authentication**.
- In the right work pane, click **DUO > Radius > Create DUO Radius Proxy Provider** from the menu.
- In the **Properties** pane, specify the following:
  - The hostname or IP address of the DUO RADIUS proxy provider.
  - The description of the DUO RADIUS proxy provider.
  - The authentication port number for the RADIUS service. The range is from 1 to 65535. The default is 1812.
  - Key is the secret text string shared between the device and a specific DUO RADIUS proxy server.
  - The timeout for communication with a DUO RADIUS proxy provider server. The range is from 1 to 60 seconds. The default is 30 seconds. If set to 0, the AAA provider timeout is used.
  - The number of retries when contacting the RADIUS endpoint. The range is from 0 to 5 retries. The default is 1.
  - The out-of-band management EPG used to communicate with the DUO RADIUS service.
  - Enabling Server Monitoring allows the connectivity of the remote AAA servers to be tested.

**Step 2** Click **Submit**.

---

## Configuring DUO LDAP Proxy Provider

Create DUO LDAP proxy providers, DUO LDAP proxy provider groups, and configure the default DUO LDAP proxy authentication settings. Create the global security management properties for DUO LDAP endpoints and DUO LDAP proxy provider groups.

### Before you begin

- The ACI fabric is installed, Application Policy Infrastructure Controllers (APICs) are online, and the APIC cluster is formed and healthy.

### Procedure

---

- Step 1** In the APIC, configure the DUO LDAP proxy provider.
- a) On the menu bar, choose **Admin > AAA**.
  - b) In the **Navigation** pane, click **Authentication**.
  - c) In the right work pane, click **DUO > LDAP > Providers > Create DUO LDAP Proxy Provider** from the menu.
  - d) In the **Properties** pane, specify the following:
    - The hostname or IP address of the DUO LDAP proxy provider.
    - The description of the DUO LDAP proxy provider.
    - The service port number for the LDAP service. The range is from 1 to 65535. The default is 389.
    - The Bind DN is the string that the APIC uses to log in to the DUO LDAP proxy server.
    - The DUO LDAP base DN to be used in a user search.
    - The password for the DUO LDAP database account specified in the **Bind DN** field.
    - The timeout for communication with an DUO LDAP proxy provider server. The range is from 0 to 60 seconds. The default is 30 seconds. If set to 0, the AAA provider timeout is used.
    - The number of retries when contacting the DUO LDAP proxy endpoint.
    - Enables an SSL connection with the DUO LDAP proxy provider. The default is disabled.
    - The attribute to be downloaded that contains user role and domain information.
      1. For DUO LDAP proxy provider server configurations with a Cisco AVPair, enter `ciscoAVPair`.
      2. For DUO LDAP proxy provider server configurations with a DUO LDAP proxy group map, enter `memberOf`.

**Note** For DUO LDAP configurations, best practice is to use `AciCiscoAVPair` as the attribute. This avoids problems related to the limitation DUO LDAP proxy servers not allowing overlapping object identifiers (OID); that is, the `ciscoAVPair` OID is already in use.

- The out-of-band management EPG used to communicate with the DUO LDAP proxy server.
- The DUO LDAP proxy provider server SSL Certificate validation level. The value can be:
  1. Permissive—A debugging knob to help diagnose DUO LDAP SSL Certificate issues.
  2. Strict—A level that should be used when in production.
- The DUO LDAP filter to be used in a user search.
- Enabling Server Monitoring allows the connectivity of the remote AAA servers to be tested.

**Step 2** Click **Submit**.

## Configuring DUO Proxy Using the REST API

The URL for all XML data :  
 POST `https://{apichost}/api/node/mo/.xml`

The following are example configurations for Duo with proxy RADIUS and proxy LDAP servers.

### RADIUS Configuration

- Add DUO RADIUS proxy provider:

```
<aaaRadiusProvider authPort="1812" authProtocol="pap" descr="duoradius"
  dn="uni/userext/duoext/radiusprovider-duoproxy.host.com"
  monitorServer="disabled" monitoringUser=""
  name="duoproxy.host.com" key="mypasswd"
  retries="1" status="created" timeout="30"/>
```

- Add Login Domain with DUO RADIUS proxy provider:

```
<aaaUserEp descr="" dn="uni/userext" name="" pwdStrengthCheck="yes" rn=""
status="modified">
  <aaaLoginDomain descr="" name="DuoRadDom" rn="logindomain-DuoRadDom" status="created">
    <aaaDomainAuth descr="" name="" providerGroup="DuoRadDom" realm="radius"
realmSubType="duo" rn="domainauth" status="created"/>
  </aaaLoginDomain>
  <aaaDuoEp descr="" name="" retries="1" rn="duoext" status="modified" timeout="40">
    <aaaDuoProviderGroup name="DuoRadDom" providerType="radius"
secFacAuthMethods="auto,push"
  rn="duoprovidergroup-DuoRadDom" status="created">
      <aaaProviderRef descr="duoradproxy" name="duoproxy.host.com" order="1"
  rn="providerref-duoproxy.host.com" status="created" />
    </aaaDuoProviderGroup>
  </aaaDuoEp>
</aaaUserEp>
```



## LDAP Configuration

- Add DUO LDAP proxy provider with the attribute `Cisco AVPair`:

```
<aaaLdapProvider name="duoproxy.host.com"
  SSLValidationLevel="strict"
  attribute="CiscoAvPair"
  basedn="CN=Users,DC=host,DC=com"
  dn="uni/userext/duoext/ldaprovider-duoproxy.host.com" enableSSL="no"
  filter="cn=$userid"
  monitorServer="disabled"
  port="389" retries="1"
  rootdn="CN=admin,CN=Users,DC=host,DC=com"
  timeout="60"
  key="12345"/>
```

- Add DUO LDAP proxy provider with the attribute `memberOf`:

```
<aaaLdapProvider name="duoproxy.host.com"
  SSLValidationLevel="strict"
  attribute="memberOf"
  basedn="CN=Users,DC=host,DC=com"
  dn="uni/userext/duoext/ldaprovider-duoproxy.host.com" enableSSL="no"
  filter="cn=$userid"
  monitorServer="disabled"
  port="389" retries="1"
  rootdn="CN=admin,CN=Users,DC=host,DC=com"
  timeout="60"
  key="12345"/>
```

- Add LDAP GroupMap rule:

```
<aaaLdapGroupMapRule name="DuoEmpRule" dn="uni/userext/duoext/ldapgroupmaprule-DuoEmpRule"
  groupdn="CN=Employee,CN=Users,DC=host,DC=com" status="created">
  <aaaUserDomain name="all" rn="userdomain-all" status="created,modified">
    <aaaUserRole name="fabric-admin" privType="writePriv" rn="role-fabric-admin"
      status="created,modified"/>
    </aaaUserDomain>
  </aaaLdapGroupMapRule>
```

- Add LDAP GroupMap:

```
<aaaLdapGroupMap name="DuoEmpGroupMap" dn="uni/userext/duoext/ldapgroupmap-DuoEmpGroupMap"
  status="created">
  <aaaLdapGroupMapRuleRef name="DuoEmpRule" rn="ldapgroupmapruleref-DuoEmpRule"
    status="created"/>
</aaaLdapGroupMap>
```

- Add DUO LDAP Login Domain using GroupMap:

```
<polUni>
  <aaaUserEp dn="uni/userext" name="" pwdStrengthCheck="yes" rn="" status="modified">
    <aaaDuoEp attribute="memberOf" basedn="" filter="sAMAccountName=$userid"
      name="" retries="1" rn="duoext" status="modified" timeout="30">
      <aaaDuoProviderGroup name="DuoLdapDom" authChoice="LdapGroupMap"
        providerType="ldap"
        rn="duoprovidergroup-DuoLdapDom" ldapGroupMapRef="DuoEmpGroupMap"
        secFacAuthMethods="auto,push" status="modified">
        <aaaProviderRef name="duoproxy.host.com" order="1"
          rn="providerref-duoproxy.host.com" status="modified"/>
      </aaaDuoProviderGroup>
    </aaaDuoEp>
  <aaaLoginDomain name="DuoLdapDom" rn="logindomain-DuoLdapDom" status="modified">
```

```

        <aaaDomainAuth name="" providerGroup="DuoLdapDom" realm="ldap"
realmSubType="duo" rn="domainauth" status="modified"/>
    </aaaLoginDomain>
</aaaUserEp>
</polUni>

```

### Get Login Domain for GUI

The GET URL for login domains:

```
GET https://apic.host.com/api/aaaListDomains.json
```

```

{
  "totalCount": "5",
  "imdata": [
    {
      "name": "DuoRadDom",
      "type": "DUO",
      "secAuths": "auto,push"
    },
    {
      "name": "DuoLdapDom",
      "type": "DUO",
      "secAuths": "auto,push"
    },
    {
      "name": "RadDom",
      "type": "OTHER"
    },
    {
      "name": "LdapDom",
      "type": "OTHER"
    },
    {
      "name": "DefaultAuth",
      "guiBanner": "",
      "type": "OTHER"
    }
  ]
}

```

## Configuring APIC for RSA Access Using the GUI

### Before you begin

- The ACI fabric is installed, Application Policy Infrastructure Controllers (APICs) are online, and the APIC cluster is formed and healthy.
- The RSA server host name or IP address, port, authorization protocol, and key are available.
- The APIC management endpoint group is available.

### Procedure

#### Step 1

In the APIC, create the RSA provider.

- On the menu bar, choose **Admin > AAA**.
- In the **Navigation** pane, choose **RSA Management > RSA Providers**.
- In the **Work** pane, choose **Actions > Create RSA Provider**.
- Specify the RSA host name (or IP address), port, protocol, and management endpoint group.

#### Step 2

Create the login domain for RSA.

- In the **Navigation** pane, choose **AAA Authentication > Login Domains**.

- b) In the **Work** pane, choose **Actions > Create Login Domain**.
- c) Specify the login domain name, description, realm, and provider group as appropriate.

---

### What to do next

This completes the APIC RSA configuration steps. Next, configure the RSA server.

## Configuring a Remote User

Instead of configuring local users, you can point the APIC at the centralized enterprise credential datacenter. The APIC supports Lightweight Directory Access Protocol (LDAP), active directory, RADIUS, and TACACS+.



**Note** When an APIC is in minority (disconnected from the cluster), remote logins can fail because the ACI is a distributed system and the user information is distributed across APICS. Local logins, however, continue to work because they are local to the APIC.

Starting with the 3.1(1) release, **Server Monitoring** can be configured through RADIUS, TACACS+, LDAP, and RSA to determine whether the respective AAA servers are alive or not. Server monitoring feature uses the respective protocol login to check for server aliveness. For example, a LDAP server will use ldap login and a Radius server will use radius login with server monitoring to determine server aliveness.

To configure a remote user authenticated through an external authentication provider, you must meet the following prerequisites:

- The DNS configuration should have already been resolved with the hostname of the RADIUS server.
- You must configure the management subnet.

## AV Pair on the External Authentication Server

The Cisco APIC requires that an administrator configure a Cisco AV Pair on an external authentication server. The Cisco AV pair specifies the APIC required RBAC roles and privileges for the user. The Cisco AV Pair format is the same for RADIUS, LDAP, or TACACS+.

To configure a Cisco AV Pair on an external authentication server, an administrator adds a Cisco AV pair to the existing user record. The Cisco AV pair format is as follows:

```
shell:domains =
domainA/writeRole1|writeRole2|writeRole3/readRole1|readRole2,
domainB/writeRole1|writeRole2|writeRole3/readRole1|readRole2
shell:domains =
domainA/writeRole1|writeRole2|writeRole3/readRole1|readRole2,
domainB/writeRole1|writeRole2|writeRole3/readRole1|readRole2(16003)
```

Starting with Cisco APIC release 2.1, if no UNIX ID is provided in AV Pair, the APIC allocates the unique UNIX user ID internally.



**Note** The APIC Cisco AV-pair format is compatible and can co-exist with other Cisco AV-pair formats. APIC will pick up the first matching AV-pair from all the AV-pairs.

Starting with release 3.1(x), the AV Pair `shell:domains=all//admin` allows you to assign Read-only privileges to users and provide them access to the switches and run commands.

The APIC supports the following regexes:

```
shell:domains\\s*[=:]\\s*((\\S+?/\\S*?/\\S*?) (, \\S+?/\\S*?/\\S*?) {0,31}) (\\(\\d+\\))$
shell:domains\\s*[=:]\\s*((\\S+?/\\S*?/\\S*?) (, \\S+?/\\S*?/\\S*?) {0,31})$
```

#### Examples:

- Example 1: A Cisco AV Pair that contains a single Security domain with only writeRoles:

```
shell:domains=domainA/writeRole1|writeRole2/
```

- Example 2: A Cisco AV Pair that contains a single Security domain with only readRoles:

```
shell:domains=domainA//readRole1|readRole2
```



**Note** The "/" character is a separator between writeRoles and readRoles per Security domain and is required even if only one type of role is to be used.

The Cisco AVpair string is case sensitive. Although a fault may not be seen, using mismatching cases for the domain name or roles could lead to unexpected privileges being given.

An example configuration for an open RADIUS server (`/etc/raddb/users`) is as follows:

```
aaa-network-admin Cleartext-Password := "<password>"
Cisco-avpair = "shell:domains = all/aaa/read-all(16001)"
```

## Best Practice for Assigning AV Pairs

As best practice, we recommend that you assign unique UNIX user IDs in the range of 16000 to 23999 for the AV pairs that are assigned to users when in the Bash shell (using SSH, Telnet, or serial/KVM consoles). If a situation arises when the Cisco AV pair does not provide a UNIX user ID, the user is assigned a user id of 23999 or similar number from the range that also enables the user's home directories, files, and processes accessible to remote users with a UNIX ID of 23999.

To ensure that your remote authentication server does not explicitly assign a UNIX ID in its cisco-av-pair response, open an SSH session to the Cisco Application Policy Infrastructure Controller (APIC) and log in as an administrator using a remote user account. After you have logged in, run the following commands (replace "`userid`" with the username with which you logged in):

```
admin@apic1:remoteuser-userid> cd /mit/uni/userext/remoteuser-userid
admin@apic1:remoteuser-userid> cat summary
```

The Cisco AV pair string is case sensitive. Although a fault may not be seen, using mismatching cases for the domain name or roles could lead to unexpected privileges being given.

## Configuring an AV Pair on the External Authentication Server

The numerical value within the parentheses in the attribute/value (AV) pair string is used as the UNIX user ID of the user who is logged in using Secure Shell (SSH) or Telnet.

### Procedure

Configure an AV pair on the external authentication server.

The Cisco AV pair definition is as follows (Cisco supports AV pairs with and without UNIX user IDs specified):

#### Example:

```
* shell:domains =
domainA/writeRole1|writeRole2|writeRole3/readRole1|readRole2,domainB/writeRole1|writeRole2|writeRole3/readRole1|readRole2

* shell:domains =
domainA/writeRole1|writeRole2|writeRole3/readRole1|readRole2,domainB/writeRole1|writeRole2|writeRole3/readRole1|readRole2(8101)
```

These are the boost regexes supported by APIC:

```
uid_regex("shell:domains\\s*[:]\s*((\\S+?/\\S+?/\\S+?) (, \\S+?/\\S+?/\\S+?) {0,31}) (\\(\\d+\\))$");
regex("shell:domains\\s*[:]\s*((\\S+?/\\S+?/\\S+?) (, \\S+?/\\S+?/\\S+?) {0,31})$");
```

The following is an example:

```
shell:domains = coke/tenant-admin/read-all,pepsi//read-all(16001)
```

## Configuring APIC for TACACS+ Access

### Before you begin

- The Cisco Application Centric Infrastructure (ACI) fabric is installed, Application Policy Infrastructure Controllers (APICs) are online, and the APIC cluster is formed and healthy.
- The TACACS+ server host name or IP address, port, and key are available.
- The APIC management endpoint group is available.

### Procedure

#### Step 1

In the APIC, create the **TACACS+ Provider**.

- On the menu bar, choose **Admin > AAA**.
- In the **Navigation** pane, choose **TACACS+ Management > TACACS+ Providers**.
- In the **Work** pane, choose **Actions > Create TACACS+ Provider**.
- Specify the TACACS+ host name (or IP address), port, authorization protocol, key, and management endpoint group.

**Note** If the APIC is configured for in-band management connectivity, out-of-band management does not work for authentication. With the APIC release 2.1(1x), you can set a global toggle between In-band and out-of-band as the default management connectivity between the APIC server and other external management devices.

For toggling in-band or out-of-band management in the APIC GUI:

- Prior to Release 2.2(1x): In the **Navigation** pane, choose **Fabric > Fabric Policies > Global Policies > Connectivity Preferences**. In the **Work Pane** select either **inband** or **ooband**.
- For Release 2.2(x) and 2.3(x): In the **Navigation** pane, choose **Fabric > Fabric Policies > Global Policies > APIC Connectivity Preferences**. In the **Work Pane** select either **inband** or **ooband**.
- For Release 3.0(1x) or later: In the **Navigation** pane, choose **System > System Settings > APIC Connectivity Preferences**. In the **Work Pane** select either **inband** or **ooband**.

**Step 2** Create the **Login Domain** for TACACS+.

- a) In the **Navigation** pane, choose **AAA Authentication > Login Domains**.
- b) In the **Work** pane, choose **Actions > Create Login Domain**.
- c) Specify the login domain name, description, realm, and provider group as appropriate.

---

### What to do next

This completes the APIC TACACS+ configuration steps. Next, if a RADIUS server will also be used, configure the APIC for RADIUS. If only a TACACS+ server will be used, go to the ACS server configuration topic below.

## Configuring APIC for RADIUS Access

### Before you begin

- The ACI fabric is installed, Application Policy Infrastructure Controllers (APICs) are online, and the APIC cluster is formed and healthy.
- The RADIUS server host name or IP address, port, authorization protocol, and key are available.
- The APIC management endpoint group is available.

### Procedure

---

**Step 1** In the APIC, create the RADIUS provider.

- a) On the menu bar, choose **Admin > AAA**.
- b) In the **Navigation** pane, click on **Authentication** and then click on the **RADIUS** tab.
- c) In the **Work** pane, choose **Actions > Create RADIUS Provider**.
- d) Specify the RADIUS host name (or IP address), port, protocol, and management endpoint group.

**Note** If the APIC is configured for in-band management connectivity, out-of-band management does not work for authentication. With the APIC release 2.1(1x), you can set a global toggle between In-band and out-of-band as the default management connectivity between the APIC server and other external management devices.

For toggling in-band or out-of-band management in the APIC GUI:

- Prior to Release 2.2(1x): In the **Navigation** pane, choose **Fabric > Fabric Policies > Global Policies > Connectivity Preferences**. In the **Work Pane** select either **inband** or **ooband**.
- For Release 2.2(x) and 2.3(x): In the **Navigation** pane, choose **Fabric > Fabric Policies > Global Policies > APIC Connectivity Preferences**. In the **Work Pane** select either **inband** or **ooband**.
- For Release 3.0(1x) or later: In the **Navigation** pane, choose **System > System Settings > APIC Connectivity Preferences**. In the **Work Pane** select either **inband** or **ooband**.

- Step 2** Create the login domain for RADIUS.
- a) In the **Navigation** pane, choose **AAA Authentication > Login Domains**.
  - b) In the **Work** pane, choose **Actions > Create Login Domain**.
  - c) Specify the login domain name, description, realm, and provider group as appropriate.

---

#### What to do next

This completes the APIC RADIUS configuration steps. Next, configure the RADIUS server.

## Configuring a Cisco Secure Access Control Server for RADIUS and TACACS+ Access to the APIC

#### Before you begin

- The Cisco Secure Access Control Server (ACS) version 5.5 is installed and online.



---

**Note** ACS v5.5 was used to document these steps. Other versions of ACS might support this task but the GUI procedures might vary accordingly.

---

- The Cisco Application Policy Infrastructure Controller (Cisco APIC) RADIUS or TACACS+ keys are available (or keys for both if both will be configured).
- The APICs are installed and online; the APIC cluster is formed and healthy.
- The RADIUS or TACACS+ port, authorization protocol, and key are available.

## Procedure

---

- Step 1** Log in to the ACS server to configure the APIC as a client.
- Navigate to **Network Resources > Network Devices Groups > Network Devices and AAA Clients**.
  - Specify the client name, the APIC in-band IP address, select the TACACS+ or RADIUS (or both) authentication options.
 

**Note** If the only RADIUS or TACACS+ authentication is needed, select only the needed option.
  - Specify the authentication details such as Shared Secret (key), and port as appropriate for the authentication option(s).
 

**Note** The **Shared Secret(s)** must match the APIC **Provider** key(s).
- Step 2** Create the Identity Group.
- Navigate to **Users and Identity Stores > Internal Groups** option.
  - Specify the **Name**, and **Parent Group** as appropriate.
- Step 3** Map users to the Identity Group.
- In the **Navigation** pane, click the **Users and Identity Stores > Internal Identity Stores > Users** option.
  - Specify the user **Name**, and **Identity Group** as appropriate.
- Step 4** Create the Policy Element.
- Navigate to the **Policy Elements** option.
  - For RADIUS, specify the Authorization and Permissions > Network Access > Authorization Profiles **Name**. For TACACS+, specify the Authorization and Permissions > Device Administration > Shell Profile **Name** as appropriate.
  - For RADIUS, specify the **Attribute** as `cisco-av-pair`, **Type** as string, and the **Value** as `shell:domains = <domain>/<role>/,<domain>// role` as appropriate. For TACACS+, specify the **Attribute** as `cisco-av-pair`, **Requirement** as Mandatory, and the **Value** as `shell:domains = <domain>/<role>/,<domain>// role` as appropriate.
- The syntax of the **Value** field determines whether write privileges are granted:
- For read/write privileges, the syntax is `shell:domains = <domain>/<role>/.`
  - For read-only privileges, the syntax is `shell:domains = <domain>// <role>.`
- For example, if the `cisco-av-pair` has a value of `shell:domains = solar/admin/,common// read-all`, then `solar` is the security domain, `admin` is the role that gives write privileges to this user in the security domain called `solar`, `common` is the tenant common, and `read-all` is the role with read privileges that gives this user read privileges to all of the tenant common.
- Step 5** Create a service selection rule.
- For RADIUS, create a service selection rule to associate the Identity Group with the Policy Element by navigating to **Access Policies > Default Device Network Access Identity > Authorization** and specifying the rule **Name**, **Status**, and **Conditions** as appropriate, and **Add** the `Internal Users:UserIdentityGroup` in `ALL Groups:<identity group name>`.



- b) For TACACS+, create a service selection rule to associate the Identity Group with the Shell Profile by navigating to **Access Policies > Default Device Admin Identity > Authorization**. Specify the rule **Name**, **Conditions**, and **Select** the **Shell Profile** as appropriate.

---

### What to do next

Use the newly created RADIUS and TACACS+ users to log in to the APIC. Verify that the users have access to the correct APIC security domain according to the assigned RBAC roles and privileges. The users should not have access to items that have not been explicitly permitted. Read and write access rights should match those configured for that user.

## Configuring LDAP

There are two options for LDAP configurations: you can configure a Cisco AVPair or configure LDAP group maps in the APIC. This section contains instructions for both configuration options.

### Configuring Windows Server 2008 LDAP for APIC Access with Cisco AVPair

#### Before you begin

- First, configure the LDAP server, then configure the Cisco Application Policy Infrastructure Controller (Cisco APIC) for LDAP access.
- The Microsoft Windows Server 2008 is installed and online.
- The Microsoft Windows Server 2008 Server Manager ADSI Edit tool is installed. To install ADSI Edit, follow the instructions in the Windows Server 2008 Server Manager help.
- `CiscoAVPair` attribute specifications: Common Name = `CiscoAVPair`, LDAP Display Name = `CiscoAVPair`, Unique X500 Object ID = 1.3.6.1.4.1.9.22.1, Description = `CiscoAVPair`, Syntax = `Case Sensitive String`.



---

**Note** For LDAP configurations, best practice is to use `CiscoAVPair` as the attribute string. If customer faces the issue using Object ID 1.3.6.1.4.1.9.22.1, an additional Object ID 1.3.6.1.4.1.9.2742.1-5 can also be used in the LDAP server.

---

- A Microsoft Windows Server 2008 user account is available that will enable the following:
  - Running ADSI Edit to add the `CiscoAVPair` attribute to the Active Directory (AD) Schema.
  - Configuring an Active Directory LDAP user to have `CiscoAVPair` attribute permissions.
- Port 636 is required for configuring LDAP integration with SSL/TLS.

#### Procedure

---

- Step 1** Log in to an Active Directory (AD) server as a domain administrator.

- Step 2** Add the `CiscoAVPair` attribute to the AD schema.
- Navigate to **Start > Run**, type `mmc` and press **Enter**.  
The Microsoft Management Console (MMC) opens.
  - Navigate to **File > Add/Remove Snap-in > Add**.
  - In the **Add Standalone Snap-in** dialog box, select the **Active Directory Schema** and click **Add**.  
The MMC Console opens.
  - Right-click the **Attributes** folder, select the **Create Attribute** option.  
The **Create New Attribute** dialog box opens.
  - Enter `CiscoAVPair` for the **Common Name**, `CiscoAVPair` for the **LDAP Display Name**, `1.3.6.1.4.1.9.22.1` for the **Unique X500 Object ID**, and select **Case Sensitive String** for the **Syntax**.
  - Click **OK** to save the attribute.

- Step 3** Update the **User Properties** class to include the `CiscoAVPair` attribute.
- In the MMC Console, expand the **Classes** folder, right-click the **user** class, and choose **Properties**.  
The **user Properties** dialog box opens.
  - Click the **Attributes** tab, and click **Add** to open the **Select Schema Object** window.
  - In the **Select a schema object:** list, choose `CiscoAVPair`, and click **Apply**.
  - In the MMC Console, right-click the **Active Directory Schema**, and select **Reload the Schema**.

- Step 4** Configure the `CiscoAVPair` attribute permissions.

Now that the LDAP includes the `CiscoAVPair` attributes, LDAP users need to be granted Cisco APIC permission by assigning them Cisco APIC RBAC roles.

- In the ADSI Edit dialog box, locate a user who needs access to the Cisco APIC.
- Right-click on the user name, and choose **Properties**.  
The `<user> Properties` dialog box opens.
- Click the **Attribute Editor** tab, select the `CiscoAVPair` attribute, and enter the *Value* as **shell:domains = <domain>/<role>/,<domain>// role**.

For example, if the `CiscoAVPair` has a value of `shell:domains = solar/admin/,common/read-all(16001)`, then `solar` is the security domain, `admin` is the role for this user that gives write privileges to this user in the security domain called `solar`, `common` is the Cisco Application Centric Infrastructure (Cisco ACI) tenant `common`, and `read-all(16001)` is the role with read privileges that gives this user read privileges to all of the Cisco ACI tenant `common`.

- Click **OK** to save the changes and close the `<user> Properties` dialog box.

---

The LDAP server is configured to access the Cisco APIC.

### What to do next

Configure the Cisco APIC for LDAP access.

## Configuring APIC for LDAP Access

### Before you begin

- The Cisco Application Centric Infrastructure (ACI) fabric is installed, Application Policy Infrastructure Controllers (APICs) are online, and the APIC cluster is formed and healthy.

- The LDAP server host name or IP address, port, bind DN, Base DN, and password are available.
- The APIC management endpoint group is available.

## Procedure

### Step 1

In the APIC, configure the LDAP Provider.

- a) On the menu bar, choose **Admin > AAA**.
- b) In the **Navigation** pane, choose **Authentication** and in the **Work** pane click on the **LDAP** tab.
- c) In the **Work** pane, choose **Actions > Create LDAP Provider**.
- d) Specify the LDAP host name (or IP address), port, bind DN, base DN, password, attribute, and management endpoint group.

#### Note

- The bind DN is the string that the APIC uses to log in to the LDAP server. The APIC uses this account to validate the remote user attempting to log in. The base DN is the container name and path in the LDAP server where the APIC searches for the remote user account. This is where the password is validated. Filter is used to locate the attribute that the APIC requests to use for the *cisco-av-pair*. This contains the user authorization and assigned RBAC roles for use on the APIC. The APIC requests the attribute from the LDAP server.
- **Attribute** field—Enter one of the following:
  - For LDAP server configurations with a Cisco AVPair, enter **CiscoAVPair**.
  - For LDAP server configurations with an LDAP group map, enter **memberOf**.
- If the APIC is configured for in-band management connectivity, choosing an out-of-band management endpoint group for LDAP access does not take effect. Alternatively, an out-of-band over an in-band management endpoint group can connect a LDAP server, but requires configuring a static route for the LDAP server. The sample configuration procedures in this document use an APIC in-band management endpoint group.

### Step 2

On the APIC, configure the login domain for LDAP.

- a) In the **Navigation** pane, choose **Authentication > Login Domains**.
- b) In the **Work** pane, choose **Actions > Create Login Domain**.
- c) Specify the login domain name, description, realm, and provider group as appropriate.

## What to do next

This completes the APIC LDAP configuration steps. Next, test the APIC LDAP login access.

## Configuring LDAP Group Map Rules on the Cisco APIC

Configuring an LDAP group map on the Cisco APIC requires first creating LDAP group map rules. This section explains how to create LDAP group map rules.

**Before you begin**

An LDAP server is running with a configured group mapping.

**Procedure**

- 
- Step 1** On the menu bar of the Cisco APIC GUI, choose **Admin > AAA**.
- Step 2** In the **Navigation** pane, expand **LDAP Management**, right-click **LDAP Group Map Rules**, and click **Create LDAP Group Map Rule**. The **Create LDAP Group Map Rule: Security** dialog appears.
- Step 3** Specify the map rule name, description (optional), group DN, and security domain in the appropriate fields then click **Next**. The **Create LDAP Group Map Rule: Roles** dialog appears with security domain options.
- Step 4** Click the + to access the Role Name and Role Privilege Type fields.
- Step 5** Click the **Role Name** drop-down arrow to choose a role name.
- Step 6** Click the **Role Privilege Type** drop-down arrow to choose a role privilege type (**Read** or **Write**) .
- Repeat Step 4 to 6 to add additional roles to the LDAP group map rule.
- Step 7** When finished, click **Finished**.
- 

**What to do next**

After specifying the LDAP group map rules, create an LDAP group map.

**Configuring an LDAP Group Map on the Cisco APIC**

Configuring an LDAP group map on the Cisco APIC requires first creating LDAP group map rules. This section explains how to create an LDAP group map.

**Before you begin**

- A running LDAP server is configured with group mapping.
- LDAP group map rules have been configured.

**Procedure**

- 
- Step 1** On the menu bar of the Cisco APIC GUI, choose **Admin > AAA**.
- Step 2** In the **Navigation** pane, expand **LDAP Management**, right-click **LDAP Group Maps**, and click **Create LDAP Group Map**. The **Create LDAP Group Map** dialog appears.
- Step 3** Specify the map name and description (optional).
- Step 4** From the **Rules** field, click the + then click the **Name** drop-down arrow to choose a specified LDAP group map rule then click **Update**.
- Repeat Step 4 to add additional rules to the LDAP group map.
- Step 5** When finished, click **Submit**.
-

## Configuring a Remote User Using the NX-OS Style CLI

Instead of configuring local users, you can point the APIC at the centralized enterprise credential datacenter. The APIC supports Lightweight Directory Access Protocol (LDAP), active directory, RADIUS, and TACACS+.

To configure a remote user authenticated through an external authentication provider, you must meet the following prerequisites:

- The DNS configuration should have already been resolved with the hostname of the RADIUS server.
- You must configure the management subnet.

## Changing the Default Behavior for Remote Users with Missing or Bad Cisco AV Pairs

### Procedure

---

- Step 1** On the menu bar, click **ADMIN > AAA**.
- Step 2** In the **Navigation** pane, click **Users**.
- Step 3** In the **Work** pane, in the **Remote Users** area, from the **Remote user login policy** drop-down list, choose **Assign Default Role**.

The default value is **No Login**. The **Assign Default Role** option assigns the minimal read-only privileges to users that have missing or bad Cisco AV Pairs. Bad AV Pairs are those AV Pairs that fail the parsing rules.

---

## Changing Default Behavior for Remote Users with Missing or Bad Cisco AV Pairs Using the NX-OS Style CLI

The Cisco APIC requires that an administrator configure a Cisco AV Pair on an external authentication server. To do so, an administrator adds a Cisco AV pair to the existing user record. The Cisco AV pair specifies the APIC required RBAC roles and privileges for the user. The Cisco AV Pair format is the same for RADIUS, LDAP, or TACACS+. One AV pair format contains a Cisco UNIX user ID and one does not. Both are correct if all remote users have the same role and mutual file access is acceptable. If the UNIX user ID is not specified, ID 23999 is applied by the APIC system, and more than one role/read privilege is specified to any AV Pair user. This can cause users to have higher or lower permissions than configured through the group settings. This topic explains how to change the behavior if that is not acceptable.

To change the default behavior for remote users with missing or bad Cisco AV pairs using the NX-OS CLI:

### Procedure

---

- Step 1** In the NX-OS CLI, start in Configuration mode.

**Example:**

```
apicl#
apicl# configure
```

**Step 2** Configure the aaa user default role.

**Example:**

```
apicl(config)# aaa user default-role
assign-default-role assign-default-role
no-login no-login
```

**Step 3** Configure the aaa authentication login methods.

**Example:**

```
apicl(config)# aaa authentication
login Configure methods for login

apicl(config)# aaa authentication login
console Configure console methods
default Configure default methods
domain Configure domain methods

apicl(config)# aaa authentication login console
<CR>

apicl(config)# aaa authentication login domain
WORD Login domain name
fallback
```

## About SAML

SAML is an XML-based open standard data format that enables administrators to access a defined set of Cisco collaboration applications seamlessly after signing into one of those applications. SAML describes the exchange of security related information between trusted business partners. It is an authentication protocol used by service providers to authenticate a user. SAML enables exchange of security authentication information between an Identity Provider (IdP) and a service provider.

SAML SSO uses the SAML 2.0 protocol to offer cross-domain and cross-product single sign-on for Cisco collaboration solutions. SAML 2.0 enables SSO across Cisco applications and enables federation between Cisco applications and an IdP. SAML 2.0 allows Cisco administrative users to access secure web domains to exchange user authentication and authorization data, between an IdP and a Service Provider while maintaining high security levels. The feature provides secure mechanisms to use common credentials and relevant information across various applications.

The authorization for SAML SSO Admin access is based on Role-Based Access Control (RBAC) configured locally on Cisco collaboration applications.

SAML SSO establishes a Circle of Trust (CoT) by exchanging metadata and certificates as part of the provisioning process between the IdP and the Service Provider. The Service Provider trusts the IdP's user information to provide access to the various services or applications.



---

**Note** Service providers are no longer involved in authentication. SAML 2.0 delegates authentication away from the service providers and to the IdPs.

---

The client authenticates against the IdP, and the IdP grants an Assertion to the client. The client presents the Assertion to the Service Provider. Since there is a CoT established, the Service Provider trusts the Assertion and grants access to the client.

Enabling SAML SSO results in several advantages:

- It reduces password fatigue by removing the need for entering different user name and password combinations.
- It transfers the authentication from your system that hosts the applications to a third party system. Using SAML SSO, you can create a circle of trust between an IdP and a service provider. The service provider trusts and relies on the IdP to authenticate the users.
- It protects and secures authentication information. It provides encryption functions to protect authentication information passed between the IdP, service provider, and user. SAML SSO can also hide authentication messages passed between the IdP and the service provider from any external user.
- It improves productivity because you spend less time re-entering credentials for the same identity.
- It reduces costs as fewer help desk calls are made for password reset, thereby leading to more savings.

## Basic Elements of SAML

- **Client (the user's client):** This is a browser-based client or a client that can leverage a browser instance for authentication. For example, a system administrator's browser.
- **Service provider:** This is the application or service that the client is trying to access.
- **An Identity Provider (IdP) server:** This is the entity that authenticates user credentials and issues SAML Assertions.
- **Lightweight Directory Access Protocol (LDAP) users:** These users are integrated with an LDAP directory, for example Microsoft Active Directory or OpenLDAP. Non-LDAP users reside locally on the Unified Communications server.
- **SAML Assertion:** It consists of pieces of security information that are transferred from IdPs to the service provider for user authentication. An assertion is an XML document that contains trusted statements about a subject including, for example, a username and privileges. SAML assertions are usually digitally signed to ensure their authenticity.
- **SAML Request:** This is an authentication request that is generated by a Unified Communications application. To authenticate the LDAP user, Unified Communications application delegates an authentication request to the IdP.
- **Circle of Trust (CoT):** It consists of the various service providers that share and authenticate against one IdP in common.
- **Metadata:** This is an XML file generated by an ACI application as well as an IdP. The exchange of SAML metadata builds a trust relationship between the IdP and the service provider.

- Assertion Consumer Service (ACS) URL: This URL instructs the IdPs where to post assertions. The ACS URL tells the IdP to post the final SAML response to a particular URL.




---

**Note** All in-scope services requiring authentication use SAML 2.0 as the SSO mechanism.

---

## Supported IdPs and SAML Components

### Supported IdPs

Identity Provider (IdP) is an authentication module that creates, maintains, and manages identity information for users, systems, or services and also provides authentication to other applications and service providers within a distributed network.

With SAML SSO, IdPs provide authentication options based on the user role or log in options for each of the Cisco collaboration applications. The IdPs store and validate the user credentials and generate a SAML response that allows the user to access the service provider protected resources.




---

**Note** You must be familiar with your IdP service, and ensure that it is currently installed and operational.

---

The APIC SAML SSO feature has been tested with following IdPs:

- [https://technet.microsoft.com/en-us/library/cc772128\(W.S.10\).aspx](https://technet.microsoft.com/en-us/library/cc772128(W.S.10).aspx)
- PingFederate: <https://documentation.pingidentity.com/pingfederate/pf90/index.shtml#gettingStartedGuide/concept/gettingStarted.html>

### SAML Components

A SAML SSO solution is based on a particular combination of assertions, protocols, bindings, and profiles. The various assertions are exchanged among applications and sites using the protocols and bindings, and those assertions authenticate the users among sites. The SAML components are as follows:

- SAML Assertion: It defines the structure and content of the information that is transferred from IdPs to service providers. It consists of packets of security information and contains statements that service providers use for various levels of access-control decisions. SAML SSO provides the following types of statements:
  - Authentication statements- These statements assert to the service provider about the method of authentication that occurs between the IdP and the browser at a particular time.
  - Attribute statements- These statements assert about certain attributes (name-value pairs) that are associated with the user. The attribute assertions contain specific information about the user. The service providers use attributes to make access-control decisions.
- SAML protocol: A SAML protocol defines how the SAML requests for and gets assertions. This protocol is responsible for the SAML request and response elements that consist of certain SAML elements or assertions. The SAML 2.0 contains the following protocols:
  - Assertion Query and Request Protocol



- Authentication Request Protocol
- SAML binding: A SAML binding specifies the mapping of SAML assertion and/or protocol message exchanges with standard messaging formats or communication protocols like SOAP exchanges. ACI supports the following SAML 2.0 bindings:
  - HTTP Redirect (GET) Binding
  - HTTP POST Binding
- SAML profile: A SAML profile provides a detailed description of the combination of SAML assertions, protocols, and bindings to support well-defined use cases.

### NTP Setup

In SAML SSO, Network Time Protocol (NTP) enables clock synchronization between the APIC and IdP. SAML is a time sensitive protocol and the IdP determines the time-based validity of a SAML assertion. If the IdP and the APIC clocks are not synchronized, the assertion becomes invalid and stops the SAML SSO feature. The maximum allowed time difference between the IdP and the APIC is 3 seconds.



---

**Note** For SAML SSO to work, you must install the correct NTP setup and make sure that the time difference between the IdP and the APIC does not exceed 3 seconds. If IdP and APIC clocks are not synchronized, the user will be redirected back to the APIC's login page even after successful authentication on IdP.

---

### DNS Setup

Domain Name System (DNS) enables the mapping of host names and network services to IP addresses within a network or networks. DNS server(s) deployed within a network provide a database that maps network services to hostnames and, in turn, hostnames to IP addresses. Devices on the network can query the DNS server and receive IP addresses for other devices in the network, thereby facilitating communication between network devices.

In summary, APIC and Idp should be able to resolve each other's fully qualified domain names to IP addresses and should be resolvable by the client.

### Certificate Authority

Cisco recommends using server certificates that are signed by one of the following types of Certificate Authority (CA):

- **Public CA**—A third-party company verifies the server identity and issues a trusted certificate.
- **Private CA**—You create and manage a local CA and issue trusted certificates.

The signing process varies for each product and can vary between server versions. It is beyond the scope of this document to provide detailed steps for every version of each server. Refer the appropriate server documentation for detailed instructions on how to get certificates signed by a CA.

If you get server certificates signed by a public CA, the public CA should already have a root certificate present in the trust store on the client computer. In this case, you do not need to import root certificates on the client computers. You should import root certificates if the certificates are signed by a CA that does not already exist in the trust store, such as a private CA. In SAML SSO, the IdP and service providers must have

CA signed certificates with the correct domains in the CN or SAN. If the correct CA certificates are not validated, the browser issues a pop up warning.

If the APIC's trust store does not include the root certificate of the IdP, a new certificate authority should be created. This Certificate Authority should be used later while configuring the SAML Provider on APIC.

## Configuring APIC for SAML Access



**Note** SAML based Authentication is only for APIC GUI and not for CLI/REST. Also, not applicable for LEAF Switches and SPINES. SAML configuration cannot be done via APIC CLI.

### Before you begin

- The Cisco Application Centric Infrastructure (ACI) fabric is installed, Application Policy Infrastructure Controllers (APICs) are online, and the APIC cluster is formed and healthy.
- The SAML server host name or IP address, and the IdP's metadata URL are available..
- The APIC management endpoint group is available.
- Set up the following:
  - Time Synchronization and NTP: [https://www.cisco.com/c/en/us/td/docs/switches/datacenter/aci/apic/sw/3-x/basic\\_config/b\\_APIC\\_Basic\\_Config\\_Guide\\_3\\_x/b\\_APIC\\_Basic\\_Config\\_Guide\\_3\\_x\\_chapter\\_011.html#concept\\_9CE11B84AD78486AA7D83A7DE1CE2A77](https://www.cisco.com/c/en/us/td/docs/switches/datacenter/aci/apic/sw/3-x/basic_config/b_APIC_Basic_Config_Guide_3_x/b_APIC_Basic_Config_Guide_3_x_chapter_011.html#concept_9CE11B84AD78486AA7D83A7DE1CE2A77).
  - Configuring a DNS Service Policy to Connect with DNS Providers Using the Advanced GUI: [https://www.cisco.com/c/en/us/td/docs/switches/datacenter/aci/apic/sw/3-x/basic\\_config/b\\_APIC\\_Basic\\_Config\\_Guide\\_3\\_x/b\\_APIC\\_Basic\\_Config\\_Guide\\_3\\_x\\_chapter\\_011.html#task\\_750E077676704BFBB5B0FE74628D821E](https://www.cisco.com/c/en/us/td/docs/switches/datacenter/aci/apic/sw/3-x/basic_config/b_APIC_Basic_Config_Guide_3_x/b_APIC_Basic_Config_Guide_3_x_chapter_011.html#task_750E077676704BFBB5B0FE74628D821E).
  - Configuring a Custom Certificate for Cisco ACI HTTPS Access Using the GUI: [https://www.cisco.com/c/en/us/td/docs/switches/datacenter/aci/apic/sw/3-x/basic\\_config/b\\_APIC\\_Basic\\_Config\\_Guide\\_3\\_x/b\\_APIC\\_Basic\\_Config\\_Guide\\_3\\_x\\_chapter\\_011.html#task\\_F037F1B75FF74ED1BCA4F3C75A16C0FA](https://www.cisco.com/c/en/us/td/docs/switches/datacenter/aci/apic/sw/3-x/basic_config/b_APIC_Basic_Config_Guide_3_x/b_APIC_Basic_Config_Guide_3_x_chapter_011.html#task_F037F1B75FF74ED1BCA4F3C75A16C0FA).

### Procedure

#### Step 1

In the APIC, create the **SAML Provider**.

- a) On the menu bar, choose **Admin > AAA**.
- b) In the **Navigation** pane, choose **SAML Management > SAML Providers**.
- c) In the **Work** pane, choose **Actions > Create SAML Provider**.
- d) Specify the SAML host name (or IP address), and IdP metadata URL.
  - In case of AD FS, IdP Metadata URL is of the format *https://<FQDN of ADFS>/FederationMetadata/2007-06/FederationMetadata.xml*.
- e) Specify the **Entity ID** for the SAML-based service.

- f) Configure the Https Proxy if it is needed to access the IdP metadata URL.
- g) Select the Certificate Authority if IdP is signed by a Private CA.
- h) Select the signature algorithm authentication type for the user requests from the drop-down.

**Step 2** Create the **Login Domain** for SAML.

- a) In the **Navigation** pane, choose **AAA Authentication > Login Domains**.
- b) In the **Work** pane, choose **Actions > Create Login Domain**.
- c) Specify the login domain name, description, realm, and provider group as appropriate.

## Setting Up a Relying Party Trust in AD FS

Add relying party trust in AD FS Management Console:

### Procedure

**Step 1** Add relying party trust:

- a) Login to AD FS Management Console on your AD FS server, Navigate to **ADFS > Trust Relationships > Relying Party Trusts** and right-click on **Add Relying Party Trust** and click **Start**.
- b) Choose **Enter data about the relying party manually** or **Import data about relying party from a file** (**skip the steps d, e, f and g**) by importing the metadata file generated using the **Download SAML Metadata** option available on the corresponding login domain setup in APIC.
- c) Enter your preferred **Display Name** for the relying party trust and click **Next**.
- d) Choose AD FS Profile and click **Next**.
- e) Click **Next** again.
- f) Select **Enable support for the SAML 2.0 Web SSO Protocol** and enter **Relying party SAML2.0 SSO service UR** as `https://<APIC_hostname>/api/aaaLoginSSO.json?name=<Login_domain_name>` and click **Next**.
- g) Enter the **Relying party trust identifier** – `https://<APIC_hostname>/api/aaaLoginSSO.json`
- h) Choose **I do not want to configure multi-factor authentication settings for this relying party trust at this time** and click **Next**.
- i) Choose **Permit all users to access this relying party** and click **Next**.
- j) Select **Open the Edit Claim rules** dialog for this relying party trust when the wizard closes and click **Close**.

**Step 2** Add the following **Claim** rules:

- a) Send LDAP Attributes as claims:
  - In the **Edit Claim Rules** window, click **Add Rule**.
  - Select the **Claim Rule Template** as Send LDAP attributes as **Claims** and click **Next**.
  - Enter a **Rule\_Name** and select **Active Directory** as the Attribute Store.
  - Select the reserved User Attribute for storing CiscoAvpair (For Ex: **Department**) as LDAP attribute type and map it to Outgoing Claim Manually Type as **CiscoAvpair**.
  - Select **E-Mail-Addresses** on LDAP Attribute and map it to the Outgoing Claim Type **E-mail Address** and click **Finish**.

- b) Transform an Incoming Claim:
- Click **Add Rule** again in the **Edit Claim Rules** window, and select **Transform an Incoming Claim as Claim Rule Template** and click **Next**.
  - Select **E-Mail Address** as the Incoming claim type.
  - Select **Name ID** as Outgoing claim type.
  - Select **Transient Identifier** as Outgoing name ID format.

**Step 3**

To add a cluster of APICs, one can either setup multiple **Relying Party Trusts** or setup single **Relying Party Trust** and add multiple **Relying Party Identifiers** and **SAML Assertion Consumer Endpoints** to it.

- a) Adding other APICs in a cluster with same relying party trusts created above.
1. Navigate to **ADFS Management Console > ADFS > Trust Relationships > Relying Party Trusts** and right-click on **CiscoAPIC > Properties**.
  2. Click on **Identifiers** tab and add other APICs in cluster as:  
*https://<APIC2\_hostname>/api/aaaLoginSSO.json, https://<APIC3\_hostname>/api/aaaLoginSSO.json*
  3. Click on **Endpoints** tab and Other two APICs by clicking on **Add SAML. Add SAML Post Binding**, Index as 1 and Enter trusted URL as:  
*https://<APIC2\_hostname>/api/aaaLoginSSO.json?name=<Login\_domain\_name>*, and **Add SAML Post Binding** as: *https://<APIC3\_hostname>/api/aaaLoginSSO.json?name=<Login\_domain\_name>*.

**Step 4**

Message and Assertion need to be signed in ADFS from powershell in ADFS server. For Signing Message and Assertion in ADFS Server:

- a) Open Windows Powershell (should be run as Administrator) and execute the below command:
  - b) Set-AdfsRelyingPartyTrust -TargetName **RelyingpartytrustnameOfCiscoAPIC** -SamlResponseSignature **MessageAndAssertion**.
-



## CHAPTER 6

# 802.1X

---

This chapter contains the following sections:

- [802.1X Overview, on page 89](#)
- [Host Support, on page 89](#)
- [Authentication Modes, on page 90](#)
- [Guidelines and Limitations, on page 90](#)
- [Configuration Overview, on page 91](#)
- [Configuring 802.1X Node Authentication Using NX-OS Style CLI, on page 94](#)
- [Configuring 802.1X Port Authentication Using the REST API, on page 94](#)
- [Configuring 802.1X Node Authentication Using the REST API, on page 95](#)

## 802.1X Overview

802.1X defines a client-server based access control and authentication protocol that restricts unauthorized clients from connecting to a LAN through publicly accessible ports. The authentication server authenticates each client connected to a Cisco NX-OS device port.

Until the client is authenticated, 802.1X access control allows only Extensible Authentication Protocol over LAN (EAPOL) traffic through the port to which the client is connected. After authentication is successful, normal traffic can pass through the port.

The RADIUS distributed client/server system allows you to secure networks against unauthorized access. In the Cisco ACI implementation, RADIUS clients run on the ToRs and send authentication and accounting requests to a central RADIUS server that contains all user authentication and network service access information.

## Host Support

The 802.1X feature can restrict traffic on a port with the following modes:

- **Single-host Mode**—Allows traffic from only one endpoint device on the 802.1X port. Once the endpoint device is authenticated, the APIC puts the port in the authorized state. When the endpoint device leaves the port, the APIC put the port back into the unauthorized state. A security violation in 802.1X is defined as a detection of frames sourced from any MAC address other than the single MAC address authorized as a result of successful authentication. In this case, the interface on which this security association violation is detected (EAPOL frame from the other MAC address) will be disabled. Single host mode is

applicable only for host-to-switch topology and when a single host is connected to the Layer 2 (Ethernet access port) or Layer 3 port (routed port) of the APIC.

- **Multi-host Mode**—Allows multiple hosts per port but only the first one gets authenticated. The port is moved to the authorized state after the successful authorization of the first host. Subsequent hosts are not required to be authorized to gain network access once the port is in the authorized state. If the port becomes unauthorized when reauthentication fails or an EAPOL logoff message is received, all attached hosts are denied access to the network. The capability of the interface to shut down upon security association violation is disabled in multiple host mode. This mode is applicable for both switch-to-switch and host-to-switch topologies
- **Multi-Auth Mode**—Allows multiple hosts and all hosts are authenticated separately.




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**Note** Each host must have the same EPG/VLAN information.

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- **Multi-Domain Mode**—For separate data and voice domain. For use with IP-Phones.

## Authentication Modes

ACI 802.1X supports the following authentication modes:

- **EAP**—The authenticator then sends an EAP-request/identity frame to the supplicant to request its identity (typically, the authenticator sends an initial identity/request frame followed by one or more requests for authentication information). When the supplicant receives the frame, it responds with an EAP-response/identity frame.
- **MAB**—MAC Authentication Bypass (MAB) is supported as the fallback authentication mode. MAB enables port-based access control using the MAC address of the endpoint. A MAB-enabled port can be dynamically enabled or disabled based on the MAC address of the device that connects to it. Prior to MAB, the endpoint's identity is unknown and all traffic is blocked. The switch examines a single packet to learn and authenticate the source MAC address. After MAB succeeds, the endpoint's identity is known and all traffic from that endpoint is allowed. The switch performs source MAC address filtering to help ensure that only the MAB-authenticated endpoint is allowed to send traffic.

## Guidelines and Limitations

802.1X port-based authentication has the following configuration guidelines and limitations:

- The Cisco ACI supports 802.1X authentication only on physical ports.
- The Cisco ACI does not support 802.1X authentication on port channels or subinterfaces.
- The Cisco ACI supports 802.1X authentication on member ports of a port channel but not on the port channel itself.
- Member ports with and without 802.1X configuration can coexist in a port channel. However, you must ensure the identical 802.1X configuration on all the member ports in order for channeling to operate with 802.1X

- When you enable 802.1X authentication, supplicants are authenticated before any other Layer 2 or Layer 3 features are enabled on an Ethernet interface.
- 802.1X is supported only on a leaf chassis that is EX or FX type.
- 802.1X is only supported Fabric Access Ports. 802.1X is not supported on Port-Channels, or Virtual-Port-Channels.
- IPv6 is not supported for dot1x clients in the 3.2(1) release.
- While downgrading to earlier releases especially in cases where certain interface config (host mode and auth type) is unsupported in that release, dot1x authentication type defaults to none. Host-mode would need to be manually re-configured to either single host/multi host depending on whatever is desired. This is to ensure that the user configures only the supported modes/auth-types in that release and doesn't run into unsupported scenarios.
- Multi-Auth supports 1 voice client and multiple data clients (all belonging to same data vlan/epg).
- Fail-epg/vlan under 802.1X node authentication policy is a mandatory configuration.
- Multi-domain more than 1 voice and 1 data client puts the port in security disabled state.
- The following platforms are not supported for 802.1X:
  - N9K-C9396PX
  - N9K-M12PQ
  - N9K-C93128TX
  - N9K-M12PQ

## Configuration Overview

The 802.1X and RADIUS processes are started only when enabled by APIC. Internally, this means dot1x process is started when 802.1X Inst MO is created and radius process is created when radius entity is created. Dot1x based authentication must be enabled on each interface for authenticating users connected on that interface otherwise the behavior is unchanged.

RADIUS server configuration is done separately from dot1x configuration. RADIUS configuration defines a list of RADIUS servers and a way to reach them. Dot1x configuration contains a reference to RADIUS group (or default group) to use for authentication.

Both 802.1X and RADIUS configuration must be done for successful authentication. Order of configuration is not important but if there is no RADIUS configuration then 802.1X authentication cannot be successful.

## Configuring 802.1X Port Authentication Using the APIC GUI

### Before you begin

Configure a RADIUS Provider policy.

## Procedure

---

- Step 1** On the menu bar, click **Fabric > External Access Policies > Policies > Interface > 802.1X Port Authentication** and perform the following actions:
- Right click on **802.1X Port Authentication**, to open **Create 802.1X Port Authentication Policy**.
  - In the **Name** field, enter a name for the policy.
  - In the **Host Mode** field, select the policy mode. The modes are:
    - **Multi Auth**—For allowing multiple hosts and all hosts are authenticated separately.
 

**Note** Each host must have the same EPG/VLAN information.
    - **Multi Domain**—For separate data and voice domain. For use with IP-Phones.
    - **Multi Host**—For allowing multiple hosts per port but only the first one gets authenticated.
    - **Single Host**—For allowing only one host per port.
  - If your device does not support 802.1X then in the **MAC Auth** field, select **EAP\_FALLBACK\_MAB** and click **Submit**.
- Step 2** To associate the **802.1X Port Authentication Policy** to a Fabric Access Group, navigate to **Fabric > External Access Policies > Interfaces > Leaf Interfaces > Policy Groups > Leaf Access Port** and perform the following actions:
- Right click on **Leaf Access Port**, to open **Create Leaf Access Port Policy Group**.
  - In the **Name** field, enter a name for the policy.
  - In the **802.1X Port Authentication Policy** field, select the policy previously created and click **Submit**.
- 

## Configuring 802.1X Node Authentication Using the APIC GUI

### Before you begin

Configure a RADIUS Provider policy.

### Procedure

---

- Step 1** On the menu bar, click **Fabric > External Access Policies > Policies > Switch > 802.1X Node Authentication** and perform the following actions:
- Right click on **802.1X Node Authentication**, to open **Create 802.1X Node Authentication Policy**.
  - In the **Name** field, enter a name for the policy.
  - In the **Failed-auth EPG** field, select the tenant, application profile, and EPG to deploy to in the case of failed authentication.
  - In the **Failed-auth VLAN**, select the VLAN to deploy to in the case of failed authentication.
- Step 2** To associate the **802.1X Node Authentication Policy** to a Leaf Switch Policy Group, navigate to **Fabric > External Access Policies > Switches > Leaf Switches > Policy Groups** and perform the following actions:
- Right click on **Policy Groups**, to open **Create Access Switch Policy Group**.



- b) In the **Name** field, enter a name for the policy.
- c) In the **802.1X Node Authentication Policy** field, select the policy previously created and click **Submit**.

**Step 3** To associate the **802.1X Node Authentication Policy** to a Leaf Interface Profile, navigate to **Fabric > External Access Policies > Interfaces > Leaf Interfaces > Profiles** and perform the following actions:

- a) Right click on **Profiles**, to open **Create Leaf Interface Profile**.
- b) In the **Name** field, enter a name for the policy.
- c) Expand the **Interface Selectors** table, to open the **Create Access Port Selector** dialog box and enter the **Name** and **Interface IDs** information.
- d) In the **Interface Policy Group** field, select the policy previously created and click **OK** and **Submit**.

## Configuring 802.1X Port Authentication Using the NX-OS Style CLI

### Procedure

**Step 1** Configure a Policy Group:

#### Example:

```
apic1# configure
apic1(config)#
apic1(config)# template policy-group mypol
apic1(config-pol-grp-if)# switchport port-authentication mydot1x
apic1(config-port-authentication)# host-mode multi-host
apic1(config-port-authentication)# no shutdown
apic1(config-port-authentication)# exit
apic1(config-pol-grp-if)# exit
```

**Step 2** Configure the leaf interface profile:

#### Example:

```
apic1(config)#
apic1(config)# leaf-interface-profile myprofile
apic1(config-leaf-if-profile)# leaf-interface-group mygroup
apic1(config-leaf-if-group)# interface ethernet 1/10-12
apic1(config-leaf-if-group)# policy-group mypol
apic1(config-leaf-if-group)# exit
apic1(config-leaf-if-profile)# exit
```

**Step 3** Configure the leaf profile:

#### Example:

```
apic1(config)#
apic1(config)# leaf-profile myleafprofile
apic1(config-leaf-profile)# leaf-group myleafgrp
apic1(config-leaf-group)# leaf 101
apic1(config-leaf-group)# exit
```

**Step 4** Apply an interface policy on the leaf switch profile:

#### Example:

```
apic1(config-leaf-profile)# leaf-interface-profile myprofile
apic1(config-leaf-group)# exit
```

---

## Configuring 802.1X Node Authentication Using NX-OS Style CLI

### Procedure

---

**Step 1** Configure the radius authentication group:

**Example:**

```
apic1# configure
apic1(config)#
apic1(config)# aaa group server radius myradiusgrp
apic1(config-radius)#server 192.168.0.100 priority 1
apic1(config-radius)#exit
```

**Step 2** Configure node level port authentication policy:

**Example:**

```
apic1(config)# policy-map type port-authentication mydot1x
apic1(config-pmap-port-authentication)#radius-provider-group myradiusgrp
apic1(config-pmap-port-authentication)#fail-auth-vlan 2001
apic1(config-pmap-port-authentication)#fail-auth-epg tenant tn1 application ap1 epg epg256
apic1(config)# exit
```

**Step 3** Configure policy group and specify port authentication policy in the group:

**Example:**

```
apic1(config)#template leaf-policy-group lpg2
apic1(config-leaf-policy-group)# port-authentication mydot1x
apic1(config-leaf-policy-group)#exit
```

**Step 4** Configure the leaf switch profile:

**Example:**

```
apic1(config)# leaf-profile mylp2
apic1(config-leaf-profile)#leaf-group mylg2
apic1(config-leaf-group)# leaf-policy-group lpg2
apic1(config-leaf-group)#exit
```

---

## Configuring 802.1X Port Authentication Using the REST API

### Procedure

---

Create a 802.1X port authentication policy:

**Example:**

```
<polUni>
<infraInfra>
  <l2PortAuthPol adminSt="enabled" annotation="" descr="" dn="uni/infra/portauthpol-test21"
  hostMode="multi-auth" name="test21" nameAlias="" ownerKey="" ownerTag="">
    <l2PortAuthCfgPol annotation="" macAuth="bypass" maxReauthReq="2" maxReq="2"
reAuthPeriod="3600" serverTimeout="30" suppTimeout="30" txPeriod="30"/>
  </l2PortAuthPol>
</infraInfra>
</polUni>
```

## Modify:

```
<polUni>
<infraInfra>
  <l2PortAuthPol adminSt="enabled" annotation="" descr="" dn="uni/infra/portauthpol-test21"
  hostMode="multi-domain" name="test21" nameAlias="" ownerKey="" ownerTag="" >
    <l2PortAuthCfgPol annotation="" macAuth="eap" maxReauthReq="2" maxReq="2"
reAuthPeriod="3600" serverTimeout="30" suppTimeout="30" txPeriod="30"/>
  </l2PortAuthPol>
</infraInfra>
</polUni>
```

## Delete:

```
<polUni>
<infraInfra>
  <l2PortAuthPol adminSt="enabled" annotation="" descr="" dn="uni/infra/portauthpol-test21"
  hostMode="multi-host" name="test21" nameAlias="" ownerKey="" ownerTag="" status="deleted">
    <l2PortAuthCfgPol annotation="" macAuth="bypass" maxReauthReq="2" maxReq="2"
reAuthPeriod="3600" serverTimeout="30" suppTimeout="30" txPeriod="30" status="deleted"/>
  </l2PortAuthPol>
</infraInfra>
</polUni>
```

## Configuring 802.1X Node Authentication Using the REST API

**Procedure**

Configure a 802.1X node authentication policy:

**Example:**

```
<polUni>
<infraInfra>
  <l2NodeAuthPol annotation="" descr="" dn="uni/infra/nodeauthpol-802-node-2"
  failAuthEpg="tn-t2,ap-ap,epg-epg1" failAuthVlan="vlan-2078" name="802-node-2" nameAlias=""
  ownerKey="" ownerTag="">
    <l2RsAaaRadiusProviderGroup annotation=""
  tDn="uni/userext/radiusext/radiusprovidergroup-radius-grp"/>
  </l2NodeAuthPol>
</infraInfra>
</polUni>
```

## Modify:

```
<polUni>
<infraInfra>
```

```

    <l2NodeAuthPol annotation="" descr="" dn="uni/infra/nodeauthpol-802-node-2"
    failAuthEpg="tn-t2,ap-ap,epg-epg1" failAuthVlan="vlan-2066" name="802-node-2" nameAlias=""
    ownerKey="" ownerTag="" status="deleted">
    <l2RsAaaRadiusProviderGroup annotation=""
    tDn="uni/userext/radiusext/radiusprovidergroup-radius-grp"/>
  </l2NodeAuthPol>
</infraInfra>
</polUni>

```

Delete:

```

<polUni>
<infraInfra>
  <l2NodeAuthPol annotation="" descr="" dn="uni/infra/nodeauthpol-802-node-2"
  failAuthEpg="tn-t2,ap-ap,epg-epg1" failAuthVlan="vlan-2078" name="802-node-2" nameAlias=""
  ownerKey="" ownerTag="" status="deleted">
  <l2RsAaaRadiusProviderGroup annotation=""
  tDn="uni/userext/radiusext/radiusprovidergroup-radius-grp" status="deleted"/>
</l2NodeAuthPol>
</infraInfra>
</polUni>

```

---



## CHAPTER 7

# Port Security

---

This chapter contains the following sections:

- [About Port Security and ACI, on page 97](#)
- [Port Security Guidelines and Restrictions, on page 97](#)
- [Port Security at Port Level , on page 98](#)
- [Port Security and Learning Behavior, on page 101](#)
- [Protect Mode, on page 101](#)
- [Confirming Your Port Security Installation Using Visore , on page 101](#)
- [Confirming Your Hardware Port Security Installation Using the Cisco NX-OS CLI, on page 102](#)

## About Port Security and ACI

The port security feature protects the ACI fabric from being flooded with unknown MAC addresses by limiting the number of MAC addresses learned per port. The port security feature support is available for physical ports, port channels, and virtual port channels.

## Port Security Guidelines and Restrictions

The guidelines and restrictions are as follows:

- Port security is available per port.
- Port security is supported for physical ports, port channels, and virtual port channels (vPCs).
- Static and dynamic MAC addresses are supported.
- MAC address moves are supported from secured to unsecured ports and from unsecured ports to secured ports.
- The MAC address limit is enforced only on the MAC address and is not enforced on a MAC and IP address.
- Port security is not supported with the Fabric Extender (FEX).

## Port Security at Port Level

In the APIC, the user can configure the port security on switch ports. Once the MAC limit has exceeded the maximum configured value on a port, all traffic from the exceeded MAC addresses is forwarded. The following attributes are supported:

- **Port Security Timeout**—The current supported range for the timeout value is from 60 to 3600 seconds.
- **Violation Action**—The violation action is available in protect mode. In the protect mode, MAC learning is disabled and MAC addresses are not added to the CAM table. Mac learning is re-enabled after the configured timeout value.
- **Maximum Endpoints**—The current supported range for the maximum endpoints configured value is from 0 to 12000. If the maximum endpoints value is 0, the port security policy is disabled on that port.

## Configuring Port Security Using the APIC GUI

### Procedure

---

- Step 1** In the menu bar, click **Fabric > Access Policies**, and in the **Navigation** pane, expand **Policies > Interface > Port Security**.
- Step 2** Right-click **Port Security** and click **Create Port Security Policy**.
- Step 3** In the **Create Port Security Policy** dialog box, perform the following actions:
- In the **Name** field, enter a name for the policy.
  - In the **Port Security Timeout** field, choose the desired value for the timeout before re-enabling MAC learning on an interface.
  - In the **Maximum Endpoints** field, choose the desired value for the maximum number of endpoints that can be learned on an interface.
  - In the **Violation Action** field, the option available is **protect**. Click **Submit**. The port security policy is created.
- Step 4** **Note** When configuring the interface for a leaf switch, the port security policy can be chosen from the list of available port security policies.

In the **Navigation** pane, click **Fabric > Inventory > Topology**, and navigate to the desired leaf switch. Choose the appropriate port to configure the interface, and from the port security policy drop-down list, choose the desired port security policy to associate.

This completes the configuration of port security on a port.

---

## Configuring Port Security Using REST API

### Procedure

---

Configure the port security.

**Example:**

```
<polUni>
  <infraInfra>

    <l2PortSecurityPol name="testL2PortSecurityPol" maximum="10" violation="protect"
    timeout="300"/>

    <infraNodeP name="test">
      <infraLeafS name="test" type="range">
        <infraNodeBlk name="test" from_"101" to_"102"/>
      </infraLeafS>
      <infraRsAccPortP tDn="uni/infra/accportprof-test"/>
    </infraNodeP>

      <infraAccPortP name="test">
        <infraHPortS name="pselc" type="range">
          <infraPortBlk name="blk"
            fromCard="1" toCard="1" fromPort="20" toPort="22">
            </infraPortBlk>
          <infraRsAccBaseGrp tDn="uni/infra/funcprof/accportgrp-testPortG" />
        </infraHPortS>
      </infraAccPortP>

      <infraFuncP>
        <infraAccPortGrp name="testPortG">
          <infraRsL2PortSecurityPol tnL2PortSecurityPolName="testL2PortSecurityPol"/>

          <infraRsAttEntP tDn="uni/infra/attentp-test" />
        </infraAccPortGrp>
      </infraFuncP>

    <infraAttEntityP name="test">
      <infraRsDomP tDn="uni/phys-mininet"/>
    </infraAttEntityP>
  </infraInfra>
</polUni>
```

## Configuring Port Security Using the CLI

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure</b> <b>Example:</b> apicl# <b>configure</b>	Enters configuration mode.
<b>Step 2</b>	<b>leaf node-id</b> <b>Example:</b> apicl (config)# <b>leaf 101</b>	Specifies the leaf to be configured.
<b>Step 3</b>	<b>interface type-or-range</b> <b>Example:</b>	Specifies an interface or a range of interfaces to be configured.

	Command or Action	Purpose
	<code>apic1(config-leaf)# interface eth 1/2-4</code>	
<b>Step 4</b>	<p><b>[no] switchport port-security maximum <i>number-of-addresses</i></b></p> <p><b>Example:</b></p> <pre>apic1(config-leaf-if)# switchport port-security maximum 1</pre>	Sets the maximum number of secure MAC addresses for the interface. The range is 0 to 12000 addresses. The default is 1 address.
<b>Step 5</b>	<p><b>[no] switchport port-security violation protect</b></p> <p><b>Example:</b></p> <pre>apic1(config-leaf-if)# switchport port-security violation protect</pre>	Sets the action to be taken when a security violation is detected. The <b>protect</b> action drops packets with unknown source addresses until you remove a sufficient number of secure MAC addresses to drop below the maximum value.
<b>Step 6</b>	<p><b>[no] switchport port-security timeout</b></p> <p><b>Example:</b></p> <pre>apic1(config-leaf-if)# switchport port-security timeout 300</pre>	Sets the timeout value for the interface. The range is from 60 to 3600. The default is 60 seconds.

### Example

This example shows how to configure port security on an Ethernet interface.

```
apic1# configure
apic1(config)# leaf 101
apic1(config-leaf)# interface eth 1/2
apic1(config-leaf-if)# switchport port-security maximum 10
apic1(config-leaf-if)# switchport port-security violation protect
apic1(config-leaf-if)# switchport port-security timeout 300
```

This example shows how to configure port security on a port channel.

```
apic1# configure
apic1(config)# leaf 101
apic1(config-leaf)# interface port-channel po2
apic1(config-leaf-if)# switchport port-security maximum 10
apic1(config-leaf-if)# switchport port-security violation protect
apic1(config-leaf-if)# switchport port-security timeout 300
```

This example shows how to configure port security on a virtual port channel (VPC).

```
apic1# configure
apic1(config)# vpc domain explicit 1 leaf 101 102
apic1(config-vpc)# exit
apic1(config)# template port-channel po4
apic1(config-if)# exit
apic1(config)# leaf 101-102
apic1(config-leaf)# interface eth 1/11-12
apic1(config-leaf-if)# channel-group po4 vpc
apic1(config-leaf-if)# exit
apic1(config-leaf)# exit
```



```
apic1(config)# vpc context leaf 101 102
apic1(config-vpc)# interface vpc po4
apic1(config-vpc-if)# switchport port-security maximum 10
apic1(config-vpc-if)# switchport port-security violation protect
apic1(config-leaf-if)# switchport port-security timeout 300
```

## Port Security and Learning Behavior

For non-vPC ports or port channels, whenever a learn event comes for a new endpoint, a verification is made to see if a new learn is allowed. If the corresponding interface has a port security policy not configured or disabled, the endpoint learning behavior is unchanged with what is supported. If the policy is enabled and the limit is reached, the current supported action is as follows:

- Learn the endpoint and install it in the hardware with a drop action.
- Silently discard the learn.

If the limit is not reached, the endpoint is learned and a verification is made to see if the limit is reached because of this new endpoint. If the limit is reached, and the learn disable action is configured, learning will be disabled in the hardware on that interface (on the physical interface or on a port channel or vPC). If the limit is reached and the learn disable action is not configured, the endpoint will be installed in hardware with a drop action. Such endpoints are aged normally like any other endpoints.

When the limit is reached for the first time, the operational state of the port security policy object is updated to reflect it. A static rule is defined to raise a fault so that the user is alerted. A syslog is also raised when the limit is reached.

In case of vPC, when the MAC limit is reached, the peer leaf switch is also notified so learning can be disabled on the peer. As the vPC peer can be rebooted any time or vPC legs can become unoperational or restart, this state will be reconciled with the peer so vPC peers do not go out of sync with this state. If they get out of sync, there can be a situation where learning is enabled on one leg and disabled on the other leg.

By default, once the limit is reached and learning is disabled, it will be automatically re-enabled after the default timeout value of 60 seconds.

## Protect Mode

The protect mode prevents further port security violations from occurring. Once the MAC limit exceeds the maximum configured value on a port, all traffic from excess MAC addresses will be dropped and further learning is disabled.

## Confirming Your Port Security Installation Using Visore

### Procedure

- 
- Step 1** On the Cisco APIC, run a query for the l2PortSecurityPol class in Visore to verify the port security policy installation.

- Step 2** On the leaf switch, run a query for l2PortSecurityPolDef in Visore to confirm that the concrete object exists on the interface.  
If you have confirmed that port security is installed on the Cisco APIC and leaf switch, use the Cisco NX-OS CLI to confirm that port security has been programmed in the hardware.

## Confirming Your Hardware Port Security Installation Using the Cisco NX-OS CLI

### Procedure

- Step 1** View the port security status on the switch interface as follows:

#### Example:

```
switch# show system internal epm interface ethernet 1/35 det
name : Ethernet1/35 ::: if index : 0x1a022000 ::: state : UP
vPC : No ::: EPT : 0x0
MAC Limit : 8 ::: Learn Disable : No ::: PortSecurity Action : Protect
VLANs : 4-23
Endpoint count : 5
Active Endpoint count : 5

switch# show system internal epm interface port-channel 1 det

name : port-channell ::: if index : 0x16000000 ::: state : UP
vPC : No ::: EPT : 0x0
MAC Limit : 6 ::: Learn Disable : No ::: PortSecurity Action : Protect
VLANs :
Endpoint count : 0
Active Endpoint count : 0
Number of member ports : 1
Interface : Ethernet1/34 /0x1a021000
:::
```

- Step 2** View the port security status on the module interface as follows:

#### Example:

```
module-1# show system internal epmc interface ethernet 1/35 det
if index : 0x1a022000 ::: name : Ethernet1/35 ::: tun_ip = 0.0.0.0
MAC limit : 8 ::: is_learn_disable : No ::: MAC limit action: Protect
pc if index : 0 ::: name :
is_vpc_fc FALSE ::: num_mem_ports : 0
interface state : up
Endpoint count : 5
EPT : 0

module-1# show system internal epmc interface port-channel 1 det
if index : 0x16000000 ::: name : port-channell ::: tun_ip = 0.0.0.0
MAC limit : 6 ::: is_learn_disable : No ::: MAC limit action: Protect
pc if index : 0 ::: name :
is_vpc_fc FALSE ::: num_mem_ports : 1
interface state : up
Endpoint count : 0
```

```
EPT : 0
::::
```

**Step 3** View the port security status on the leaf switch as follows:

**Example:**

```
swtb15-leaf2# show system internal epm interface ethernet 1/35 det

name : Ethernet1/35 ::: if index : 0x1a022000 ::: state : UP
vPC : No ::: EPT : 0x0
MAC Limit : 5 ::: Learn Disable : Yes ::: PortSecurity Action : Protect
VLANs : 4-23
Endpoint count : 5
Active Endpoint count : 5
::::
```

**Step 4** Confirm the MAC limit on the module interface as follows:

**Example:**

```
module-1# show system internal eltmc info interface port-channel1 | grep mac_limit
mac_limit_reached:          0   ::: mac_limit:          8
port_sec_feature_set:       1   ::: mac_limit_action:    1
```

**Example:**

```
module-1# show system internal eltmc info interface ethernet 1/35 | grep mac_limit
mac_limit_reached:          0   ::: mac_limit:          8
port_sec_feature_set:       1   ::: mac_limit_action:    1
```

**Step 5** View the port security status in the module and confirm the MAC limit as follows:

**Example:**

```
module-1# show system internal ePMC interface ethernet 1/35 det
if index : 0x1a022000 ::: name : Ethernet1/35 ::: tun_ip = 0.0.0.0
MAC limit : 5 ::: is_learn_disable : Yes ::: MAC limit action: Protect
pc if index : 0 ::: name :
is_vpc_fc FALSE ::: num_mem_ports : 0
interface state : up
Endpoint count : 5
EPT : 0
::::
```

**Example:**

```
module-1# show system internal eltmc info interface ethernet 1/35 | grep mac_limit
mac_limit_reached:          1   ::: mac_limit:          5
port_sec_feature_set:       1   ::: mac_limit_action:    1
module-1# exit
```





## CHAPTER 8

# First Hop Security

---

This chapter contains the following sections:

- [About First Hop Security, on page 105](#)
- [ACI FHS Deployment, on page 106](#)
- [Guidelines and Limitations, on page 106](#)
- [Configuring FHS Using the APIC GUI, on page 107](#)
- [Configuring FHS Using the NX-OS CLI, on page 107](#)
- [FHS Switch iBASH Commands, on page 114](#)
- [Configuring FHS in APIC Using REST API, on page 119](#)

## About First Hop Security

First-Hop Security (FHS) features enable a better IPv4 and IPv6 link security and management over the layer 2 links. In a service provider environment, these features closely control address assignment and derived operations, such as Duplicate Address Detection (DAD) and Address Resolution (AR).

The following supported FHS features secure the protocols and help build a secure endpoint database on the fabric leaf switches, that are used to mitigate security threats such as MIM attacks and IP thefts:

- **ARP Inspection**—allows a network administrator to intercept, log, and discard ARP packets with invalid MAC address to IP address bindings.
- **ND Inspection**—learns and secures bindings for stateless autoconfiguration addresses in Layer 2 neighbor tables.
- **DHCP Inspection**—validates DHCP messages received from untrusted sources and filters out invalid messages.
- **RA Guard**—allows the network administrator to block or reject unwanted or rogue router advertisement (RA) guard messages.
- **IPv4 and IPv6 Source Guard**—blocks any data traffic from an unknown source.
- **Trust Control**—a trusted source is a device that is under your administrative control. These devices include the switches, routers, and servers in the Fabric. Any device beyond the firewall or outside the network is an untrusted source. Generally, host ports are treated as untrusted sources.

FHS features provide the following security measures:

- **Role Enforcement**—Prevents untrusted hosts from sending messages that are out the scope of their role.
- **Binding Enforcement**—Prevents address theft.
- **DoS Attack Mitigations**—Prevents malicious end-points to grow the end-point database to the point where the database could stop providing operation services.
- **Proxy Services**—Provides some proxy-services to increase the efficiency of address resolution.

FHS features are enabled on a per tenant bridge domain (BD) basis. As the bridge domain, may be deployed on a single or across multiple leaf switches, the FHS threat control and mitigation mechanisms cater to a single switch and multiple switch scenarios.

## ACI FHS Deployment

Most FHS features are configured in a two-step fashion: firstly you define a policy which describes the behavior of the feature, secondly you apply this policy to a "domain" (being the Tenant Bridge Domain or the Tenant Endpoint Group). Different policies that define different behaviors can be applied to different intersecting domains. The decision to use a specific policy is taken by the most specific domain to which the policy is applied.

The policy options can be defined from the Cisco APIC GUI found under the Tenant\_<name>Networking>Protocol Policies>First Hop Security tab.

## Guidelines and Limitations

Follow these guidelines and limitations:

- Starting with release 3.1(1), FHS is supported with virtual Endpoints (AVS only).
- FHS is supported with both VLAN and VXLAN encapsulation.
- Any secured endpoint entry in the FHS Binding Table Database in **DOWN** state will get cleared after **18 Hours** of timeout. The entry moves to **DOWN** state when the front panel port where the entry is learned is link down. During this window of **18 Hours**, if the endpoint is moved to a different location and is seen on a different port, the entry will be gracefully moved out of **DOWN** state to **REACHABLE/STALE** as long as the endpoint is reachable from the other port it is moved from.
- When IP Source Guard is enabled, the IPv6 traffic that is sourced using IPv6 Link Local address as IP source address is not subject to the IP Source Guard enforcement (i.e. Enforcement of Source Mac <=> Source IP Bindings secured by IP Inspect Feature). This traffic is permitted by default irrespective of binding check failures.
- FHS is not supported on L3Out interfaces.
- FHS is not supported N9K-M12PQ based TORs.
- FHS in ACI Multi-Site is a site local capability therefore it can only be enabled in a site from the APIC cluster. Also, FHS in ACI Multi-Site only works when the BD and EPG is site local and not stretched across sites. FHS security cannot be enabled for stretched BD or EPGs.
- FHS is not supported on a Layer 2 only bridge domain.

- Enabling FHS feature can disrupt traffic for 50 seconds because the EP in the BD are flushed and EP Learning in the BD is disabled for 50 seconds.

## Configuring FHS Using the APIC GUI

### Before you begin

- The tenant and Bridge Domain configured.

### Procedure

---

- Step 1** On the menu bar, click **Tenants > Tenant\_name**. In the **Navigation** pane, click **Policies > Protocol > First Hop Security**. Right click on **First Hop Security** to open **Create Feature Policy** and perform the following actions:
- In the **Name** field, enter a name for the First Hop Security policy.
  - Verify that the **IP Inspection**, **Source Guard**, and **Router Advertisement** fields are enabled and click **Submit**.
- Step 2** In the **Navigation** pane, expand **First Hop Security** and right click on **Trust Control Policies** to open **Create Trust Control Policy** and perform the following actions:
- In the **Name** field, enter a name for the Trust Control policy.
  - Select the desired features to be allowed on the policy and click **Submit**.
- Step 3** (Optional) To apply the Trust Control policy to an EPG, in the **Navigation** pane, expand **Application Profiles > Application Profile\_name > Application EPGs** and click on **Application EPG\_name** and perform the following actions:
- In the **Work** pane, click on the **General** tab.
  - Click on the down-arrow for **FHS Trust Control Policy** and select the policy you previously created and click **Submit**.
- Step 4** In the **Navigation** pane, expand **Bridge Domains > Bridge Domain\_name** and click on the **Advanced/Troubleshooting** tab and perform the following action:
- In the **First Hop Security Policy** field, select the policy you just created and click **Submit**. This completes FHS configuration.
- 

## Configuring FHS Using the NX-OS CLI

### Before you begin

- The tenant and Bridge Domain configured.

## Procedure

---

### Step 1 configure

Enters configuration mode.

#### Example:

```
apicl# configure
```

### Step 2 Configure FHS policy.

#### Example:

```
apicl(config)# tenant coke
apicl(config-tenant)# first-hop-security
apicl(config-tenant-fhs)# security-policy poll
apicl(config-tenant-fhs-secpol)#
apicl(config-tenant-fhs-secpol)# ip-inspection-admin-status enabled-both
apicl(config-tenant-fhs-secpol)# source-guard-admin-status enabled-both
apicl(config-tenant-fhs-secpol)# router-advertisement-guard-admin-status enabled
apicl(config-tenant-fhs-secpol)# router-advertisement-guard
apicl(config-tenant-fhs-raguard)#
apicl(config-tenant-fhs-raguard)# managed-config-check
apicl(config-tenant-fhs-raguard)# managed-config-flag
apicl(config-tenant-fhs-raguard)# other-config-check
apicl(config-tenant-fhs-raguard)# other-config-flag
apicl(config-tenant-fhs-raguard)# maximum-router-preference low
apicl(config-tenant-fhs-raguard)# minimum-hop-limit 10
apicl(config-tenant-fhs-raguard)# maximum-hop-limit 100
apicl(config-tenant-fhs-raguard)# exit
apicl(config-tenant-fhs-secpol)# exit
apicl(config-tenant-fhs)# trust-control tcpoll
apicl(config-tenant-fhs-trustctrl)# arp
apicl(config-tenant-fhs-trustctrl)# dhcpv4-server
apicl(config-tenant-fhs-trustctrl)# dhcpv6-server
apicl(config-tenant-fhs-trustctrl)# ipv6-router
apicl(config-tenant-fhs-trustctrl)# router-advertisement
apicl(config-tenant-fhs-trustctrl)# neighbor-discovery
apicl(config-tenant-fhs-trustctrl)# exit
apicl(config-tenant-fhs)# exit
apicl(config-tenant)# bridge-domain bd1
apicl(config-tenant-bd)# first-hop-security security-policy poll
apicl(config-tenant-bd)# exit
apicl(config-tenant)# application ap1
apicl(config-tenant-app)# epg epg1
apicl(config-tenant-app-epg)# first-hop-security trust-control tcpoll
```

### Step 3 Show FHS configuration example:

#### Example:

```
leaf4# show fhs bt all
```

#### Legend:

TR	: trusted-access	UNRES	: unresolved	Age
:	Age since creation			
UNTR	: untrusted-access	UNDTR	: undetermined-trust	CRTNG
:	creating			
UNKNW	: unknown	TENTV	: tentative	INV
:	invalid			
NDP	: Neighbor Discovery Protocol	STA	: static-authenticated	REACH
:	reachable			



```

    INCMP      : incomplete                                VERIFY : verify                                INTF
: Interface
    TimeLeft   : Remaining time since last refresh      LM      : lla-mac-match                        DHCP
: dhcp-assigned

```

EPG-Mode:

```

    U : unknown    M : mac    V : vlan    I : ip

```

```

BD-VNID      BD-Vlan      BD-Name
15630220     3                    t0:bd200

```

```

-----
| Origin | IP                | MAC                | INTF | EPG(sclass)(mode) | Trust-lvl |
| State | Age              | TimeLeft           |      |                    |           |
-----
| ARP    | 192.0.200.12     | D0:72:DC:A0:3D:4F | eth1/1 | ep300(49154)(V)   | LM,TR    |
| STALE  | 00:04:49 | 18:08:13 |      |                    |           |
| ARP    | 172.29.205.232   | D0:72:DC:A0:3D:4F | eth1/1 | ep300(49154)(V)   | LM,TR    |
| STALE  | 00:03:55 | 18:08:21 |      |                    |           |
| ARP    | 192.0.200.21     | D0:72:DC:A0:3D:4F | eth1/1 | ep300(49154)(V)   | LM,TR    |
| REACH  | 00:03:36 | 00:00:02 |      |                    |           |
| LOCAL  | 192.0.200.1      | 00:22:BD:F8:19:FF | vlan3  | LOCAL(16387)(I)   | STA      |
| REACH  | 04:49:41 | N/A      |      |                    |           |
| LOCAL  | fe80::200        | 00:22:BD:F8:19:FF | vlan3  | LOCAL(16387)(I)   | STA      |
| REACH  | 04:49:40 | N/A      |      |                    |           |
| LOCAL  | 2001:0:0:200::1 | 00:22:BD:F8:19:FF | vlan3  | LOCAL(16387)(I)   | STA      |
| REACH  | 04:49:39 | N/A      |      |                    |           |
-----

```

The trust levels are:

- **TR**— Trusted. Displayed when the endpoint is learned from an EPG where the trust configuration is enabled.
- **UNTR**— Untrusted. Displayed when the endpoint is learned from an EPG where the trust configuration is not enabled.
- **UNDTR**— Undetermined. Displayed in the case of a DHCP relay topology where the DHCP server bridge domain (BD) is on a remote leaf and the DHCP clients are on a local leaf. In this situation, the local leaf will not know whether the DHCP server BD has trust DHCP enabled.

#### Step 4 Show violations with the different types and reasons example:

##### Example:

```
leaf4# show fhs violations all
```

Violation-Type:

```

POL : policy      THR : address-theft-remote
ROLE : role       TH  : address-theft
INT  : internal

```

Violation-Reason:

```

IP-MAC-TH      : ip-mac-theft                                OCFG_CHK  : ra-other-cfg-check-fail
ANC-COL        : anchor-collision
PRF-LVL-CHK    : ra-rtr-pref-level-check-fail                INT-ERR    : internal-error
TRUST-CHK      : trust-check-fail
SRV-ROL-CHK    : srv-role-check-fail                        ST-EP-COL  : static-ep-collision
LCL-EP-COL     : local-ep-collision
MAC-TH         : mac-theft                                  EP-LIM     : ep-limit-reached
MCFG-CHK       : ra-managed-cfg-check-fail
HOP-LMT-CHK    : ra-hoplimit-check-fail                      MOV-COL    : competing-move-collision
RTR-ROL-CHK    : rtr-role-check-fail

```

```

IP-TH      : ip-theft

EPG-Mode:
  U : unknown   M : mac   V : vlan   I : ip

BD-VNID      BD-Vlan      BD-Name
15630220      3                  t0:bd200
-----
| Type | Last-Reason | Proto | IP          | MAC              | Port   | EPG(sclass) (mode)
| Count |            |      |            |                  |       |
-----
| THR  | IP-TH      | ARP   | 192.0.200.21 | D0:72:DC:A0:3D:4F | tunnel5 | epg300 (49154) (V)
| 21  |            |      |              |                  |       |
-----
Table Count: 1

```

**Step 5** Show FHS configuration:**Example:**

```
swtb23-ifc1# show tenant t0 bridge-domain bd200 first-hop-security binding-table
```

Pod/Node	Type	Family	IP Address	MAC Address	Interface	Level
1/102	local reach	ipv4	192.0.200.1	00:22:BD:F8:19:FF	vlan3	static-
1/102	local reach	ipv6	fe80::200	00:22:BD:F8:19:FF	vlan3	static-
1/102	local reach	ipv6	2001:0:0:200::1	00:22:BD:F8:19:FF	vlan3	static-
1/101	arp stale	ipv4	192.0.200.23	D0:72:DC:A0:02:61	eth1/2	lla-mac-match ,untrusted- access static-
1/101	local reach	ipv4	192.0.200.1	00:22:BD:F8:19:FF	vlan3	static-
1/101	nd reach	ipv6	fe80::d272:dcff:fea0:261	D0:72:DC:A0:02:61	eth1/2	lla-mac-match ,untrusted- access
1/101	nd stale	ipv6	2001:0:0:200::20	D0:72:DC:A0:02:61	eth1/2	lla-mac-match ,untrusted- access
1/101	nd stale	ipv6	2001::200:d272:dcff:fea0:261	D0:72:DC:A0:02:61	eth1/2	lla-mac-match ,untrusted- access
1/101	local reach	ipv6	fe80::200	00:22:BD:F8:19:FF	vlan3	access static-

```

authenticated   able
1/101    local  ipv6   2001:0:0:200::1      00:22:BD:F8:19:FF  vlan3      static-
      reach

authenticated   able
1/103    local  ipv4   192.0.200.1         00:22:BD:F8:19:FF  vlan4      static-
      reach

authenticated   able
1/103    local  ipv6   fe80::200           00:22:BD:F8:19:FF  vlan4      static-
      reach

authenticated   able
1/103    local  ipv6   2001:0:0:200::1     00:22:BD:F8:19:FF  vlan4      static-
      reach

authenticated   able
1/104    arp    ipv4   192.0.200.10        F8:72:EA:AD:C4:7C  eth1/1     lla-mac-match
      stale

,trusted-access
1/104    arp    ipv4   172.29.207.222      D0:72:DC:A0:3D:4C  eth1/1     lla-mac-match
      stale

,trusted-access
1/104    local  ipv4   192.0.200.1         00:22:BD:F8:19:FF  vlan4      static-
      reach

authenticated   able
1/104    nd     ipv6   fe80::fa72:eaff:fea  F8:72:EA:AD:C4:7C  eth1/1     lla-mac-match
      stale
      :c47c

,trusted-access
1/104    nd     ipv6   2001:0:0:200::10    F8:72:EA:AD:C4:7C  eth1/1     lla-mac-match
      stale

,trusted-access
1/104    local  ipv6   fe80::200           00:22:BD:F8:19:FF  vlan4      static-
      reach

authenticated   able
1/104    local  ipv6   2001:0:0:200::1     00:22:BD:F8:19:FF  vlan4      static-
      reach

authenticated   able

```

```

Pod/Node  Type  IP Address          Creation TS          Last Refresh TS
      Lease Period
-----
1/102    local  192.0.200.1        2017-07-20T04:22:38.000+00:00
2017-07-20T04:22:38.000+00:00
1/102    local  fe80::200          2017-07-20T04:22:56.000+00:00
2017-07-20T04:22:56.000+00:00
1/102    local  2001:0:0:200::1    2017-07-20T04:22:57.000+00:00
2017-07-20T04:22:57.000+00:00
1/101    arp    192.0.200.23      2017-07-27T10:55:20.000+00:00
2017-07-27T16:07:24.000+00:00
1/101    local  192.0.200.1        2017-07-27T10:48:09.000+00:00
2017-07-27T10:48:09.000+00:00
1/101    nd     fe80::d272:dcff:fea 2017-07-27T10:52:16.000+00:00
2017-07-27T16:04:29.000+00:00
      :261

```

```

1/101    nd      2001:0:0:200::20      2017-07-27T10:57:32.000+00:00
2017-07-27T16:07:24.000+00:00
1/101    nd      2001::200:d272:dcff:  2017-07-27T11:21:45.000+00:00
2017-07-27T16:07:24.000+00:00
          fea0:261
1/101    local   fe80::200              2017-07-27T10:48:10.000+00:00
2017-07-27T10:48:10.000+00:00
1/101    local   2001:0:0:200::1      2017-07-27T10:48:11.000+00:00
2017-07-27T10:48:11.000+00:00
1/103    local   192.0.200.1          2017-07-26T22:03:56.000+00:00
2017-07-26T22:03:56.000+00:00
1/103    local   fe80::200              2017-07-26T22:03:57.000+00:00
2017-07-26T22:03:57.000+00:00
1/103    local   2001:0:0:200::1      2017-07-26T22:03:58.000+00:00
2017-07-26T22:03:58.000+00:00
1/104    arp     192.0.200.10         2017-07-27T11:21:13.000+00:00
2017-07-27T16:05:48.000+00:00
1/104    arp     172.29.207.222       2017-07-27T11:54:48.000+00:00
2017-07-27T16:06:38.000+00:00
1/104    local   192.0.200.1          2017-07-27T10:49:13.000+00:00
2017-07-27T10:49:13.000+00:00
1/104    nd      fe80::fa72:eaff:fead  2017-07-27T11:21:13.000+00:00
2017-07-27T16:06:43.000+00:00
          :c47c
1/104    nd      2001:0:0:200::10     2017-07-27T11:21:13.000+00:00
2017-07-27T16:06:19.000+00:00
1/104    local   fe80::200              2017-07-27T10:49:14.000+00:00
2017-07-27T10:49:14.000+00:00
1/104    local   2001:0:0:200::1      2017-07-27T10:49:15.000+00:00
2017-07-27T10:49:15.000+00:00

```

```
swtb23-ifc1#
```

```
swtb23-ifc1# show tenant t0 bridge-domain bd200 first-hop-security statistics arp
```

```

Pod/Node      : 1/101
Request Received : 4
Request Switched : 2
Request Dropped : 2
Reply Received  : 257
Reply Switched  : 257
Reply Dropped   : 0

```

```

Pod/Node      : 1/104
Request Received : 6
Request Switched : 6
Request Dropped : 0
Reply Received  : 954
Reply Switched  : 954
Reply Dropped   : 0

```

```
swtb23-ifc1# show tenant t0 bridge-domain bd200 first-hop-security statistics dhcpv4
```

```

Pod/Node      : 1/102
Discovery Received : 5
Discovery Switched : 5
Discovery Dropped : 0
Offer Received    : 0
Offer Switched    : 0
Offer Dropped     : 0
Request Received  : 0
Request Switched  : 0
Request Dropped   : 0
Ack Received      : 0
Ack Switched      : 0

```

```

Ack Dropped : 0
Nack Received : 0
Nack Switched : 0
Nack Dropped : 0
Decline Received : 0
Decline Switched : 0
Decline Dropped : 0
Release Received : 0
Release Switched : 0
Release Dropped : 0
Information Received : 0
Information Switched : 0
Information Dropped : 0
Lease Query Received : 0
Lease Query Switched : 0
Lease Query Dropped : 0
Lease Active Received : 0
Lease Active Switched : 0
Lease Active Dropped : 0
Lease Unassignment Received : 0
Lease Unassignment Switched : 0
Lease Unassignment Dropped : 0
Lease Unknown Received : 0
Lease Unknown Switched : 0
Lease Unknown Dropped : 0

```

```

swtb23-ifc1# show tenant t0 bridge-domain bd200 first-hop-security statistics
neighbor-discovery

```

```

Pod/Node : 1/101
Neighbor Solicitation Received : 125
Neighbor Solicitation Switched : 121
Neighbor Solicitation Dropped : 4
Neighbor Advertisement Received : 519
Neighbor Advertisement Switched : 519
Neighbor Advertisement Drop : 0
Router Solicitation Received : 4
Router Solicitation Switched : 4
Router Solicitation Dropped : 0
Router Adv Received : 0
Router Adv Switched : 0
Router Adv Dropped : 0
Redirect Received : 0
Redirect Switched : 0
Redirect Dropped : 0

```

```

Pod/Node : 1/104
Neighbor Solicitation Received : 123
Neighbor Solicitation Switched : 47
Neighbor Solicitation Dropped : 76
Neighbor Advertisement Received : 252
Neighbor Advertisement Switched : 228
Neighbor Advertisement Drop : 24
Router Solicitation Received : 0
Router Solicitation Switched : 0
Router Solicitation Dropped : 0
Router Adv Received : 53
Router Adv Switched : 6
Router Adv Dropped : 47
Redirect Received : 0
Redirect Switched : 0
Redirect Dropped : 0

```

# FHS Switch iBASH Commands

## Procedure

**Step 1** Show command to display the FHS feature configuration on the BD and the Trust control policy configuration on the EPG:

### Example:

```
leaf4# show fhs features all
```

```
BD-VNID          BD-Vlan          BD-Name
15630220         4                t0:bd200
  Feature Policy:
    Feature      Family      Protocol      Operational-State      Options
    ipinspect    IPV4        ARP           UP                      stalelifetime: 180s
    ipinspect    IPV4        DHCP          UP                      -
    ipinspect    IPV4        LOCAL        UP                      -
    ipinspect    IPV4        STATIC       UP                      -
    ipinspect    IPV6        ND           UP                      stalelifetime: 180s
    ipinspect    IPV6        DHCP          UP                      -
    ipinspect    IPV6        LOCAL        UP                      -
    ipinspect    IPV6        STATIC       UP                      -
    rguard       IPV6        -            UP                      ManagedCfgFlag: on
                                                OtherCfgFlag: on
                                                maxHopLimit: 15
                                                minHopLimit: 3
                                                routerPref: medium
```

```
-----
Trust Policy:
```

```
Epg-id          Epg-type          Epg-name
49154           Ckt-Vlan          epg300
  Trust-Attribute      Operational-State
  PROTO-ARP            UP
  PROTO-ND             UP
  DHCPV4-SERVER        UP
  DHCPV6-SERVER        UP
  ROUTER               UP
```

**Step 2** Show commands to display the FHS secured endpoint database:

### Example:

```
leaf1# show fhs bt
all      data      dhcpv4    local    static
arp      detailed  dhcpv6    nd       summary
```

```
leaf1# show fhs bt all
```

```
Legend:
```

```
  DHCP      : dhcp-assigned          TR      : trusted-access          UNRES
: unresolved
  Age       : Age since creation     CRTNG   : creating            TENTV
: tentative
  VERIFY    : verify                 UNDTR   : undetermined-trust   INV
: invalid
  NDP       : Neighbor Discovery Protocol STA     : static-authenticated     REACH
: reachable
  LM        : lla-mac-match          UNKNW   : unknown                  INTF
: Interface
```

```

    TimeLeft : Remaining time since last refresh      INCMP : incomplete      UNTR
: untrusted-access

```

```
EPG-Mode:
```

```
U : unknown      M : mac      V : vlan      I : ip
```

```
BD-VNID          BD-Vlan          BD-Name
15630220         3                t0:bd200
```

Trust-lvl	Origin	IP	Age	TimeLeft	MAC	INTF	EPG(sclass) (mode)
LM,UNTR	ARP	192.0.200.23	00:07:47	00:01:33	D0:72:DC:A0:02:61	eth1/2	epg200(32770) (V)
		STATE					
LOCAL	LOCAL	192.0.200.1	00:14:58	N/A	00:22:BD:F8:19:FF	vlan3	LOCAL(16387) (I)   STA
		REACH					
LM,UNTR	NDP	fe80::d272:dcff:fea0:261	00:10:51	00:00:47	D0:72:DC:A0:02:61	eth1/2	epg200(32770) (V)
		STATE					
LM,UNTR	NDP	2001:0:0:200::20	00:05:35	00:00:42	D0:72:DC:A0:02:61	eth1/2	epg200(32770) (V)
		STATE					
LOCAL	LOCAL	fe80::200	00:14:58	N/A	00:22:BD:F8:19:FF	vlan3	LOCAL(16387) (I)   STA
		REACH					
LOCAL	LOCAL	2001:0:0:200::1	00:14:57	N/A	00:22:BD:F8:19:FF	vlan3	LOCAL(16387) (I)   STA
		REACH					

```
leaf1# show fhs bt summary all
```

```
-----
                          FHS Binding Table Summary
-----
```

```
BD-Vlan: 3          BD-Name: t0:bd200
Total number of ARP entries      : 1
Total number of DHCPv4 entries   : 0
Total number of ND entries       : 2
Total number of DHCPv6 entries   : 0
Total number of Data entries     : 0
Total number of Static entries   : 0
Total number of Local entries    : 3
Total number of entries          : 6
```

```
-----
Total entries across all BDs matching given filters
Total number of ARP entries      : 1
Total number of DHCPv4 entries   : 0
Total number of ND entries       : 2
Total number of DHCPv6 entries   : 0
Total number of Data entries     : 0
Total number of Static entries   : 0
Total number of Local entries    : 3
Total number of entries          : 6
-----
```

### Step 3 Show command to display FHS endpoint violations:

#### Example:

```
leaf1# show fhs violations all
```

```
Violation-Type:
POL : policy      THR : address-theft-remote
ROLE : role       TH  : address-theft
INT  : internal
```

```

Violation-Reason:
  IP-MAC-TH      : ip-mac-theft          OCFG_CHK  : ra-other-cfg-check-fail
  ANC-COL        : anchor-collision
  PRF-LVL-CHK    : ra-rtr-pref-level-check-fail  INT-ERR   : internal-error
  TRUST-CHK      : trust-check-fail
  SRV-ROL-CHK    : srv-role-check-fail         ST-EP-COL : static-ep-collision
  LCL-EP-COL     : local-ep-collision
  MAC-TH         : mac-theft                 EP-LIM    : ep-limit-reached
  MCFG-CHK       : ra-managed-cfg-check-fail    MOV-COL   : competing-move-collision
  HOP-LMT-CHK    : ra-hoplmit-check-fail
  RTR-ROL-CHK    : rtr-role-check-fail
  IP-TH          : ip-theft

```

```

Trust-Level:
  TR  : trusted-access      UNTR : untrusted-access      UNDTR : undetermined-trust
  INV : invalid             STA  : static-authenticated   LM    : lla-mac-match
  DHCP : dhcp-assigned

```

```

EPG-Mode:
  U : unknown      M : mac      V : vlan      I : ip

```

```

BD-VNID      BD-Vlan      BD-Name
15630220     4                t0:bd200

```

Type	Last-Reason	Proto	IP	MAC	Port
EPG(sclass) (mode)	Trust-lvl	Count			
TH	IP-TH	ND	2001:0:0:200::20	D0:72:DC:A0:3D:4F	eth1/1
epg300 (49154) (V)	LM, UNTR	2			
POL	HOP-LMT-CHK	RD	fe80::fa72:eaff:fead:c47c	F8:72:EA:AD:C4:7C	eth1/1
epg300 (49154) (V)	LM, TR	2			

Table Count: 2

#### Step 4 Show command to display FHS control packet forwarding counters:

##### Example:

```

leaf1# show fhs counters
all arp dhcpv4 dhcpv6 nd
leaf4# show fhs counters all

```

```

BD-VNID      BD-Vlan      BD-Name
15630220     4                t0:bd200

```

Counter Type	Received	Switched	Dropped
Arp Request	6	6	0
Arp Reply	94	94	0
Dhcpv4 Ack	0	0	0
Dhcpv4 Decline	0	0	0
Dhcpv4 Discover	0	0	0
Dhcpv4 Inform	0	0	0
Dhcpv4 Leaseactive	0	0	0
Dhcpv4 Leasequery	0	0	0



Dhcpv4 Leaseunassigned	0		0		0
Dhcpv4 Leaseunknown	0		0		0
Dhcpv4 Nack	0		0		0
Dhcpv4 Offer	0		0		0
Dhcpv4 Release	0		0		0
Dhcpv4 Request	0		0		0
-----					
Dhcpv6 Advertise	0		0		0
Dhcpv6 Confirm	0		0		0
Dhcpv6 Decline	0		0		0
Dhcpv6 Informationreq	0		0		0
Dhcpv6 Rebind	0		0		0
Dhcpv6 Reconfigure	0		0		0
Dhcpv6 Relayforw	0		0		0
Dhcpv6 Relayreply	0		0		0
Dhcpv6 Release	0		0		0
Dhcpv6 Renew	0		0		0
Dhcpv6 Reply	0		0		0
Dhcpv6 Request	0		0		0
Dhcpv6 Solicit	0		0		0
-----					
Nd Na	18		18		0
Nd Ns	26		22		4
Nd Ra	11		6		5
Nd Redirect	0		0		0
Nd Rs	0		0		0
-----					

**Step 5** Display FHS secured endpoint database from the NxOS memory:

**Example:**

```
leaf1# vsh -c 'show system internal fhs bt'
```

```
Binding Table has 7 entries, 4 dynamic
```

Codes:

```
L - Local          S - Static          ND - Neighbor Discovery  ARP - Address Resolution
Protocol
DH4 - IPv4 DHCP   DH6 - IPv6 DHCP   PKT - Other Packet      API - API created
```

```

Preflevel flags (prlvl):
0001: MAC and LLA match      0002: Orig trunk          0004: Orig access
0008: Orig trusted trunk    0010: Orig trusted access 0020: DHCP assigned
0040: Cga authenticated     0080: Cert authenticated  0100: Statically assigned

```

EPG types:

V - Vlan Based EPG      M - MAC Based EPG      I - IP Based EPG

Code	Network Layer Address	Link Layer Address	Interface			
Vlan	Epg	prlvl	Age	State	Time left	
4	ARP   172.29.207.222	d0:72:dc:a0:3d:4c	Eth1/1	0011	29 s	STALE   157 s
4	L   192.0.200.1	00:22:bd:f8:19:ff	Vlan4	0100	55 mn	REACHABLE
4	ARP   192.0.200.10	f8:72:ea:ad:c4:7c	Eth1/1	0011	156 s	STALE   30 s
4	L   2001:0:0:200::1	00:22:bd:f8:19:ff	Vlan4	0100	55 mn	REACHABLE
4	ND   2001:0:0:200::10	f8:72:ea:ad:c4:7c	Eth1/1	0011	143 s	STALE   47 s
4	L   fe80::200	00:22:bd:f8:19:ff	Vlan4	0100	55 mn	REACHABLE
4	ND   fe80::fa72:eaff:fead:c47c	f8:72:ea:ad:c4:7c	Eth1/1	0011	176 s	STALE   11 s

**Step 6** Display FHS feature configuration from the NX-OS FHS process internal memory:

**Example:**

```
leaf4# vsh -c 'show system internal fhs pol'
```

```

Target          Type Policy          Feature          Target-Range Sub-Feature
epg 0x40000c002 EPG  epg 0x40000c002 Trustctrl      vlan 4      Device-Roles:
DHCPv4-Server, DHCPv6-Server, Router
                                           Protocols: ARP ND
vlan 4          VLAN  vlan 4          IP inspect      vlan all     Protocols: ARP, DHCPv4,
ND, DHCPv6,
vlan 4          VLAN  vlan 4          RA guard        vlan all     Min-HL:3, Max-HL:15,
M-Config-flag:Enable,On
                                           O-Config-flag:Enable,On,
Router-Pref:medium

```

**Step 7** Display FHS secured endpoint database from the NX-OS shared database:

**Example:**

```
leaf1# vsh -c 'show system internal fhs sdb bt'
```

```

Preflevel flags (prelvl):
0001: MAC and LLA match      0002: Orig trunk          0004: Orig access
0008: Orig trusted trunk    0010: Orig trusted access 0020: DHCP assigned
0040: Cga authenticated     0080: Cert authenticated  0100: Statically assigned

```

Origin ID	Zone ID	L3 Address	MAC Address	VLAN
EPG ID		If-name	Prevlvl	State
ARP	0x4	172.29.207.222	d0:72:dc:a0:3d:4c	4
	0x40000c002	Eth1/1	0011	STALE
L	0x4	192.0.200.1	00:22:bd:f8:19:ff	4

```

0x400004003      Vlan4      0100      REACHABLE
ARP      0x4      192.0.200.10      f8:72:ea:ad:c4:7c      4
0x40000c002      Eth1/1     0011      REACHABLE
L      0x4      2001:0:0:200::1    00:22:bd:f8:19:ff      4
0x400004003      Vlan4      0100      REACHABLE
ND      0x4      2001:0:0:200::10  f8:72:ea:ad:c4:7c      4
0x40000c002      Eth1/1     0011      STALE
L      0x80000004 fe80::200    00:22:bd:f8:19:ff      4
0x400004003      Vlan4      0100      REACHABLE
ND      0x80000004 fe80::fa72:eaff:fead:c47c f8:72:ea:ad:c4:7c      4
0x40000c002      Eth1/1     0011      STALE

```

**Step 8** Display FHS feature configurations from the NxOS shared database:

**Example:**

```
leaf1# vsh -c 'show system internal fhs sdb pol'
Policies:
```

```

IP inspect      Vlan 4      Protocols:ARP DHCPv4 ND DHCPv6
RA guard      Vlan 4      Min-HL:3 Max-HL:15 M-Config-Flag:enable,on
O-Config-Flag:enable,on Router-Pref:medium
Trustctrl      Epg 0x40000c002      Vlan:4
Device-Roles:DHCPv4-Server DHCPv6-Server Router
Protocols:ARP ND

```

**Step 9** Show command to clear a secured database endpoint entry:

**Example:**

```
leaf1# vsh -c 'clear system internal fhs bt ipv4 172.29.207.222'
```

## Configuring FHS in APIC Using REST API

### Before you begin

- The tenant and bridge domain must be configured.

### Procedure

Configure the FHS and Trust Control policies.

**Example:**

```

<polUni>
  <fvTenant name="Coke">
    <fhsBDPol name="bdpol5" ipInspectAdminSt="enabled-ipv6" srcGuardAdminSt="enabled-both"
raGuardAdminSt="enabled" status="">
      <fhsRaGuardPol name="raguard5" managedConfigCheck="true" managedConfigFlag="true"
otherConfigCheck="true" otherConfigFlag="true" maxRouterPref="medium" minHopLimit="3"
maxHopLimit="15" status=""/>
    </fhsBDPol>
  <fvBD name="bd3">
    <fvRsBDToFhs tnFhsBDPolName="bdpol5" status=""/>
  </fvBD>
</fvTenant>
</polUni>

```

```
<polUni>
<fvTenant name="Coke">
  <fhsTrustCtrlPol name="trustctrl5" hasDhcpv4Server="true" hasDhcpv6Server="true"
hasIpv6Router="true" trustRa="true" trustArp="true" trustNd="true" />
  <fvAp name="wwwCokecom3">
    <fvAEPg name="test966">
      <fvRsTrustCtrl tnFhsTrustCtrlPolName="trustctrl5" status="" />
    </fvAEPg>
  </fvAp>
</fvTenant>
</polUni>
```

---



## CHAPTER 9

# Protocol Authentication

This chapter contains the following sections:

- [COOP, on page 121](#)
- [EIGRP, on page 123](#)

## COOP

### Overview

Council of Oracle Protocol (COOP) is used to communicate the mapping information (location and identity) to the spine proxy. A leaf switch forwards endpoint address information to the spine switch 'Oracle' using Zero Message Queue (ZMQ). COOP running on the spine nodes will ensure all spine nodes maintain a consistent copy of endpoint address and location information and additionally maintain the distributed hash table (DHT) repository of endpoint identity to location mapping database.

COOP data path communication provides high priority to transport using secured connections. COOP is enhanced to leverage the MD5 option to protect COOP messages from malicious traffic injection. The APIC controller and switches support COOP protocol authentication.

COOP protocol is enhanced to support two ZMQ authentication modes: strict and compatible.

- Strict mode: COOP allows MD5 authenticated ZMQ connections only.
- Compatible mode: COOP accepts both MD5 authenticated and non-authenticated ZMQ connections for message transportation.

### Using COOP with Cisco APIC

To support COOP Zero Message Queue (ZMQ) authentication support across the Cisco Application Centric Infrastructure (ACI) fabric, the Application Policy Infrastructure Controller (APIC) supports the MD5 password and also supports the COOP secure mode.

COOP ZMQ Authentication Type Configuration—A new managed object, `coop:AuthP`, is added to the Data Management Engine (DME)/COOP database (`coop/inst/auth`). The default value for the attribute type is "compatible", and users have the option to configure the type to be "strict".

COOP ZMQ Authentication MD5 password—The APIC provides a managed object (`fabric:SecurityToken`), that includes an attribute to be used for the MD5 password. An attribute in this managed object, called "token", is a string that changes every hour. COOP obtains the notification from the DME to update the password for ZMQ authentication. The attribute token value is not displayed.

## Guidelines and Limitations

Follow these guidelines and limitations:

- During an ACI fabric upgrade, the COOP strict mode is disallowed until all switches are upgraded. This protection prevents the unexpected rejection of a COOP connection that could be triggered by prematurely enabling the strict mode.

## Configuring COOP Authentication Using the APIC GUI

### Procedure

---

- Step 1** On the menu bar, choose **System > System Settings**.
- Step 2** In the **Navigation** pane, click on **COOP Group**.
- Step 3** In the **Work** pane, under the **Policy Property** area in the **Type** field, choose the desired type from the **Compatible Type** and **Strict Type** options.
- Step 4** Click **Submit**.  
This completes the COOP authentication policy configuration.
- 

## Configuring COOP Authentication Using the Cisco NX-OS-Style CLI

### Procedure

---

Configure the COOP authentication policy using the strict mode option.

#### Example:

```
apic1# configure
apic1(config)# coop-fabric
apic1(config-coop-fabric)# authentication type ?
compatible  Compatible type
strict      Strict type
apic101-apic1(config-coop-fabric)# authentication type strict
```

---

# Configuring COOP Authentication Using the REST API

## Procedure

---

Configure a COOP authentication policy.

In the example, the strict mode is chosen.

### Example:

```
https://172.23.53.xx/api/node/mo/uni/fabric/pol-default.xml
```

```
<coopPol type="strict">  
</coopPol>
```

---

## EIGRP

### Overview

EIGRP combines the benefits of distance vector protocols with the features of link-state protocols. EIGRP sends out periodic Hello messages for neighbor discovery. Once EIGRP learns a new neighbor, it sends a one-time update of all the local EIGRP routes and route metrics. The receiving EIGRP router calculates the route distance based on the received metrics and the locally assigned cost of the link to that neighbor. After this initial full route table update, EIGRP sends incremental updates to only those neighbors affected by the route change. This process speeds convergence and minimizes the bandwidth used by EIGRP.

For Cisco APIC, EIGRP Authentication uses Route-map's keychain infrastructure for MD5 Authentication. It takes two parameters to configure Authentication between two EIGRP peers. The parameters are:

- Mode
- Keychain

### Guidelines and Limitations

Follow these guidelines and limitations:

- Only MD5 Authentication is supported. Keychain is the Keychain name configured under RPM.
- When there is authentication mismatch between two EIGRP peers, then neighborhood flaps. The reason for the flap can be verified in **show eigrp internal event-history syslog**.

## Configuring EIGRP Authentication Using the APIC GUI

### Procedure

---

- Step 1** On the menu bar, choose **Tenant***tenant-name*.
- Step 2** In the **Navigation** pane, expand **Policies > Protocol > EIGRP**.
- Step 3** Expand **EIGRP** and right-click **EIGRP KeyChains** to open **Create Keychain Policy** and perform the following actions:
- In the **Name** field, enter a name for the policy.
  - In the **KeyID** field, enter a key ID number.
  - In the **Preshared key** field, enter the preshared key information.
  - Optional. In the **Start Time** and **End Time** fields, enter a time.
- Step 4** In the **Navigation** pane, right-click on **EIGRP Interface** and perform the following actions:
- In the **Authentication** field, click the box to enable.
  - In the **Key Chain Policy** field, select the policy just created from the drop-down and click **Submit**.
- 

## Configuring EIGRP Authentication Using the NX-OS CLI

### Procedure

---

- Step 1** Configure keychain-policy and key-policy under Tenant.
- Example:**
- ```
tenant T1
keychain-policy KeyChainPol
key-policy 2
```
- Step 2** Optional. Configure Start time.
- Example:**
- ```
starttime 2018-11-01T08:39:27.000+00:00
exit
```
- Step 3** Enter the leaf configuration from APIC. Enable authentication in the interface and configure the key-chain policy.
- Example:**
- ```
IFC1(config-leaf)# show run
# Command: show running-config leaf 104
# Time: Thu Nov 8 12:05:45 2018
leaf 104
interface ethernet 1/2.45
vrf member tenant T1 vrf V1 l3out L3Out
ip router eigrp authentication keychain-policy KeyChainPol
ip router eigrp authentication enable
!
ipv6 router eigrp authentication keychain-policy KeyChainPol
```



```
ipv6 router eigrp authentication enable
exit
```

**Step 4** To verify EIGRP configuration:

**Example:**

```
fav-blr4-ls-leaf4# show ip eigrp interfaces eth1/2.17
EIGRP interfaces for process 1 VRF T1:V1
Xmit Queue Mean Pacing Time Multicast Pending
Interface Peers Un/Reliable SRTT Un/Reliable Flow Timer Routes
eth1/2.17 0 0/0 0 0/0 50 0
Hello interval is 5 sec
Holdtime interval is 15 sec
Next xmit serial: 0
Un/reliable mcasts: 0/3 Un/reliable ucasts: 6/4
Mcast exceptions: 0 CR packets: 0 ACKs suppressed: 1
Retransmissions sent: 0 Out-of-sequence rcvd: 0
Classic/wide metric peers: 0/0
Authentication mode is md5, key-chain is T1:KeyChainPol
ifav-blr4-ls-leaf4#
```

**Step 5** For troubleshooting it on a switch, following CLIs can be used. And EIGRP Auth is supported on both IPv4 and IPv6 address families.

**Example:**

```
(none)# show ip eigrp interface vrf all
EIGRP interfaces for process 100 VRF pepsi
Xmit Queue Mean Pacing Time Multicast Pending
Interface Peers Un/Reliable SRTT Un/Reliable Flow Timer Routes
eth1/1 1 0/0 207 0/0 828 0
Hello interval is 10 sec
Holdtime interval is 15 sec
Next xmit serial: 0
Un/reliable mcasts: 0/7 Un/reliable ucasts: 21/18
Mcast exceptions: 0 CR packets: 0 ACKs suppressed: 0
Retransmissions sent: 4 Out-of-sequence rcvd: 2
Classic/wide metric peers: 0/1
Authentication mode is md5, key-chain is eigrp-auth

(none)# show ipv6 eigrp interface vrf pepsi
IPv6-EIGRP interfaces for process 100 VRF pepsi
Xmit Queue Mean Pacing Time Multicast Pending
Interface Peers Un/Reliable SRTT Un/Reliable Flow Timer Routes
eth1/1 0 0/0 0 0/0 0 0
Hello interval is 10 sec
Holdtime interval is 15 sec
Next xmit serial: 0
Un/reliable mcasts: 0/0 Un/reliable ucasts: 0/0
Mcast exceptions: 0 CR packets: 0 ACKs suppressed: 0
Retransmissions sent: 0 Out-of-sequence rcvd: 0
Classic/wide metric peers: 0/0
Authentication mode is md5, key-chain is eigrp-auth
```

---





## CHAPTER 10

# Control Plane Traffic

---

- [About Control Plane Policing, on page 127](#)
- [About CoPP Prefilters, on page 135](#)

## About Control Plane Policing

Control plane policing (CoPP) protects the control plane, which ensures network stability, reachability, and packet delivery.

This feature allows specification of parameters, for each protocol that can reach the control processor to be rate-limited using a policer. The policing is applied to all traffic destined to any of the IP addresses of the router or Layer 3 switch. A common attack vector for network devices is the denial-of-service (DoS) attack, where excessive traffic is directed at the device interfaces.

The Cisco Application Centric Infrastructure (ACI) leaf and spine switch NX-OS provides CoPP to prevent DoS attacks from impacting performance. Such attacks, which can be perpetrated either inadvertently or maliciously, typically involve high rates of traffic destined to the supervisor module of a Cisco ACI leaf and spine switch CPU or CPU itself.

The supervisor module of Cisco ACI leaf and spine switch switches divides the traffic that it manages into two functional components or planes:

- **Data plane**—Handles all the data traffic. The basic functionality of a Cisco NX-OS device is to forward packets from one interface to another. The packets that are not meant for the switch itself are called the transit packets. These packets are handled by the data plane.
- **Control plane**—Handles all routing protocol control traffic. These protocols, such as the Border Gateway Protocol (BGP) and the Open Shortest Path First (OSPF) Protocol, send control packets between devices. These packets are destined to router addresses and are called control plane packets.

The Cisco ACI leaf and spine switch supervisor module has a control plane and is critical to the operation of the network. Any disruption or attacks to the supervisor module will result in serious network outages. For example, excessive traffic to the supervisor module could overload and slow down the performance of the entire Cisco ACI fabric. Another example is a DoS attack on the Cisco ACI leaf and spine switch supervisor module that could generate IP traffic streams to the control plane at a very high rate, forcing the control plane to spend a large amount of time in handling these packets and preventing the control plane from processing genuine traffic.

Examples of DoS attacks are as follows:

- Internet Control Message Protocol (ICMP) echo requests
- IP fragments
- TCP SYN flooding

These attacks can impact the device performance and have the following negative effects:

- Reduced service quality (such as poor voice, video, or critical applications traffic)
- High route processor or switch processor CPU utilization
- Route flaps due to loss of routing protocol updates or keepalives
- Processor resource exhaustion, such as the memory and buffers
- Indiscriminate drops of incoming packets




---

**Note** Cisco ACI leaf and spine switches are by default protected by CoPP with default settings. This feature allows for tuning the parameters on a group of nodes based on customer needs.

---

### Control Plane Protection

To protect the control plane, the Cisco NX-OS running on Cisco ACI leaf and spine switches segregates different packets destined for the control plane into different classes. Once these classes are identified, the Cisco NX-OS device polices the packets, which ensures that the supervisor module is not overwhelmed.

#### Control Plane Packet Types:

Different types of packets can reach the control plane:

- **Receive Packets**—Packets that have the destination address of a router. The destination address can be a Layer 2 address (such as a router MAC address) or a Layer 3 address (such as the IP address of a router interface). These packets include router updates and keepalive messages. Multicast packets can also be in this category where packets are sent to multicast addresses that are used by a router.
- **Exception Packets**—Packets that need special handling by the supervisor module. For example, if a destination address is not present in the Forwarding Information Base (FIB) and results in a miss, the supervisor module sends an ICMP unreachable packet back to the sender. Another example is a packet with IP options set.
- **Redirect Packets**—Packets that are redirected to the supervisor module. Features such as Dynamic Host Configuration Protocol (DHCP) snooping or dynamic Address Resolution Protocol (ARP) inspection redirect some packets to the supervisor module.
- **Glean Packets**—If a Layer 2 MAC address for a destination IP address is not present in the FIB, the supervisor module receives the packet and sends an ARP request to the host.

All of these different packets could be maliciously used to attack the control plane and overwhelm the Cisco ACI fabric. CoPP classifies these packets to different classes and provides a mechanism to individually control the rate at which the Cisco ACI leaf and spine switch supervisor module receives these packets.

#### Classification for CoPP:

For effective protection, the Cisco ACI leaf and spine switch NX-OS classifies the packets that reach the supervisor modules to allow you to apply different rate controlling policies based on the type of the packet. For example, you might want to be less strict with a protocol packet such as Hello messages but more strict with a packet that is sent to the supervisor module because the IP option is set.

#### Available Protocols:

| Protocol  | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Glean     | With this protocol, when the bridge domain is in proxy mode, unknown unicast traffic received by the leaf switch is sent to the hardware proxy (the spine switch). The spine switch changes the eth-type of the packet to a special eth-type (0xfff2). When these packets reach the leaf switches through the fabric ports, the packets are classified under glean. The packets are sent to the leaf switch's CPU, and the leaf switch's CPU generates an ARP request for the connected external devices. |
| ToR Glean | ToR glean activates when an endpoint moves or is cleared because of link flap and does not update the source leaf switch's remote IP address endpoint entry. A packet egresses the source leaf switch with the destination leaf switch's TEP address. On the destination leaf switch, because of the missing local IP address entry, the packet gets sent to the leaf switch CPU to generate an ARP request for those IP addresses. These packets are classified under ToR glean.                         |

#### Rate Controlling Mechanisms:

Once the packets are classified, the Cisco ACI leaf and spine switch NX-OS has different mechanisms to control the rate at which packets arrive at the supervisor module.

You can configure the following parameters for policing:

- **Committed information rate (CIR)**—Desired bandwidth, specified as a bit rate or a percentage of the link rate.
- **Committed burst (BC)**—Size of a traffic burst that can exceed the CIR within a given unit of time and not impact scheduling.

#### Default Policing Policies:

When the Cisco ACI leaf and spine switch is bootup, the platform setup pre-defined CoPP parameters for different protocols are based on the tests done by Cisco.

## Guidelines and Limitations for CoPP

CoPP has the following configuration guidelines and limitations:

- We recommend that you use the default CoPP policy initially and then later modify the CoPP policies based on the data center and application requirements.

- Customizing CoPP is an ongoing process. CoPP must be configured according to the protocols and features used in your specific environment as well as the supervisor features that are required by the server environment. As these protocols and features change, CoPP must be modified.
- We recommend that you continuously monitor CoPP. If drops occur, determine if CoPP dropped traffic unintentionally or in response to a malfunction or attack. In either event, analyze the situation and evaluate the need to modify the CoPP policies.
- You must ensure that the CoPP policy does not filter critical traffic such as routing protocols or interactive access to the device. Filtering this traffic could prevent remote access to the Cisco ACI Leaf/Spine and require a console connection.
- Do not mis-configure CoPP pre-filter entries. CoPP pre-filter entries might impact connectivity to multi-pod configurations, remote leaf switches, and Cisco ACI Multi-Site deployments.
- You can use the APIC UI to be able to tune the CoPP parameters.
- Per interface per protocol is only supported on Leaf switches.
- FEX ports are not supported on per interface per protocol.
- For per interface per protocol the supported protocols are; ARP, ICMP, CDP, LLDP, LACP, BGP, STP, BFD, and OSPF.
- The TCAM entry maximum for per interface per protocol is 256. Once the threshold is exceeded a fault will be raised.

## Configuring CoPP Using the APIC GUI

### Procedure

- 
- Step 1** On the menu bar, click **Fabric > Access Policies**.
- Step 2** In the **Navigation** pane, right-click **Policies > Switch > CoPP Leaf** and choose **Create CoPP Leaf Level Policy**.
- Step 3** In the **Create CoPP Leaf Level Policy** dialog, perform the following substeps:
- In the **Name** field, enter the policy name.
  - In the **Type of Profile** field, choose the profile type.
 

**Note** Choose **CoPP has custom values** if you wish to set each protocol separately. If you do not choose a profile type then the default values are applied.
  - Click **Submit**.
- Step 4** In the **Navigation** pane, right-click **Switches > Leaf Switches > Policy Groups** and choose **Create Access Switch Policy Group**.
- Step 5** In the **Create Access Switch Policy Group** dialog, perform the following substeps:
- In the **Name** field, enter the policy name.
  - In the **CoPP Leaf Policy** field, choose the policy that you previously created.
  - Click **Submit**.
- Step 6** In the **Navigation** pane, right-click **Switches > Leaf Switches > Profiles** and choose **Create Leaf Profile**.

- Step 7** In the **Create Leaf Profile** dialog, perform the following substeps:
- In the **Name** field, enter the profile name.
  - In the **Leaf Selectors** table, click +, enter a name for the leaf selector in the **Name** field, choose the switches in the **Blocks** field, choose the **Policy Group** that you previously created, and click **Update**.
  - Click **Next** then **Finish** to complete the CoPP configuration.
- 

## Configuring CoPP Using the Cisco NX-OS CLI

### Procedure

---

- Step 1** Configure a CoPP leaf profile:

**Example:**

```
# configure copp Leaf Profile
apic1(config)# policy-map type control-plane-leaf leafProfile
apic1(config-pmap-copp-leaf)# profile-type custom
apic1(config-pmap-copp-leaf)# set arpRate 786
# create a policy group to be applied on leaves
apic1(config)# template leaf-policy-group coppForLeaves
apic1(config-leaf-policy-group)# copp-aggr leafProfile
apic1(config-leaf-policy-group)# exit
# apply the leaves policy group on leaves
apic1(config)# leaf-profile applyCopp
apic1(config-leaf-profile)# leaf-group applyCopp
apic1(config-leaf-group)# leaf 101-102
apic1(config-leaf-group)# leaf-policy-group coppForLeaves
```

- Step 2** Configure a CoPP Spine profile:

**Example:**

```
# configure copp Spine Profile
apic1(config)# policy-map type control-plane-spine spineProfile
apic1(config-pmap-copp-spine)# profile-type custom
apic1(config-pmap-copp-spine)# set arpRate 786
# create a policy group to be applied on spines
apic1(config)# template leaf-policy-group coppForSpines
apic1(config-spine-policy-group)# copp-aggr spineProfile
apic1(config-spine-policy-group)# exit
# apply the spine policy group on spines
apic1(config)# spine-profile applyCopp
apic1(config-spine-profile)# spine-group applyCopp
apic1(config-spine-group)# spine 201-202
apic1(config-spine-group)# spine-policy-group coppForSpines
```

---

## Configuring CoPP Using the REST API

### Procedure

**Step 1** Configure a CoPP leaf profile:

#### Example:

```
<!-- api/node/mo/uni/.xml -->
<infraInfra>
  <coppLeafProfile type="custom" name="mycustom">                                <!-- define copp leaf
profile -->
    <coppLeafGenlCustomValues bgpBurst="150" bgpRate="300"/>
  </coppLeafProfile>
  <infraNodeP name="leafCopp">
    <infraLeafS name="leafs" type="range">
      <infraNodeBlk name="leaf1" from_"101" to_"101"/>
      <infraNodeBlk name="leaf3" from_"103" to_"103"/>
      <infraRsAccNodePGrp tDn="uni/infra/funcprof/accnodepgrp-myLeafCopp"/>
    </infraLeafS>
  </infraNodeP>
  <infraFuncP>
    <infraAccNodePGrp name="myLeafCopp">
      <infraRsLeafCoppProfile tnCoppLeafProfileName="mycustom"/>    <!-- bind copp leaf
policy to leaf </infraAccNodePGrp>
    </infraFuncP>
  </infraInfra>
```

**Step 2** Configure a CoPP spine profile:

#### Example:

```
<!-- api/node/mo/uni/.xml -->
<infraInfra>
  <coppSpineProfile type="custom" name="mycustomSpine">                        <!-- define copp leaf
profile -->
    <coppSpineGenlCustomValues bgpBurst="150" bgpRate="300"/>
  </coppSpineProfile>
  <infraSpineP name="spineCopp">
    <infraSpineS name="spines" type="range">
      <infraNodeBlk name="spine1" from_"104" to_"104"/>
      <infraRsSpineAccNodePGrp tDn="uni/infra/funcprof/spaccnodepgrp-mySpineCopp"/>
    </infraSpineS>
  </infraSpineP>
  <infraFuncP>
    <infraSpineAccNodePGrp name="mySpineCopp">
      <infraRsSpineCoppProfile tnCoppSpineProfileName="mycustomSpine"/> <!-- bind copp spine
policy to
      </infraSpineAccNodePGrp>  spine profile
    </infraFuncP>
  </infraInfra>
```



## Viewing CoPP Statistics Using the GUI

Fine tuning CoPP requires knowing the number of packets dropped/allowed by a given protocol on a given node. The information can be viewed in the GUI using the procedure below:

### Procedure

---

On the menu bar, click **Fabric > Inventory > Podnumber > Nodename > Control Plane Statistics > default**, select from the list of classes to configure the statistics display format.

You can collect statistics about the number of packets allowed or dropped by CoPP.

---

## Configuring Per Interface Per Protocol CoPP Policy Using the APIC GUI

### Procedure

---

- Step 1** On the menu bar, click **Fabric > External Access Policies**.
- Step 2** In the **Navigation** pane, expand **Policies > Interface > CoPP Interface**, right click **Create Per Interface Per Protocol CoPP Policy** dialog box to perform the following actions in the **Create Per Interface Per Protocol CoPP Policy** dialog box:
- In the **Name** field, add a policy name.
  - Expand the **CoPP policy Protocol** table, and enter the protocol name, type, rate, and burst information. Click **Update** and **Submit**.
- Step 3** In the **Navigation** pane, expand **Interfaces > Leaf Interfaces > Policy Groups > Create Leaf Access Port Policy Group**, right click **Create Leaf Access Port Policy Group** dialog box to perform the following actions in the **Create Leaf Access Port Policy Group** dialog box:
- In the **Name** field, add a policy name.
  - In the **CoPP Leaf Policy** field, select the policy previously created.
  - Click **Submit**.
- Step 4** In the **Navigation** pane, expand **Interfaces > Leaf Interfaces > Profiles > Leaf Profiles**, right click **Create Leaf Interface Profile** dialog box to perform the following actions in the **Create Leaf Interface Profile** dialog box:
- In the **Name** field, add a profile name.
  - Expand the **Interface Selectors** table, add the interface information in the **Name** and **Interface IDs** fields, and select the **Interface Policy Group** previously created.
  - Click **Ok** and **Submit** to complete Per Interface Per Protocol CoPP configuration.
-

## Configuring Per Interface Per Protocol CoPP Policy Using the NX-OS Style CLI

### Procedure

---

**Step 1** Define the CoPP class map and policy map:

**Example:**

```
(config)# policy-map type control-plane-if <name>
      (config-pmap-copp)# protocol bgp bps <value>
      (config-pmap-copp)# protocol ospf bps <value>
```

**Step 2** Applying the configuration to an interface on the leaf:

**Example:**

```
(config)# leaf 101
      (config-leaf)# int eth 1/10
      (config-leaf-if)# service-policy type control-plane-if output<name>
```

---

## Configuring CoPP Per Interface Per Protocol Using REST API

### Procedure

---

Configure a CoPP per interface per protocol:

**Example:**

```
<polUni>
  <infraInfra>
    <infraNodeP name="default">
      <infraLeafS name="default" type="range">
        <infraNodeBlk name="default" to_"101" from_"101"/>
      </infraLeafS>
      <infraRsAccPortP tDn="uni/infra/accportprof-default"/>
    </infraNodeP>
    <infraAccPortP name="default">
      <infraHPortS name="regularPorts" type="range">
        <infraPortBlk name="blk1" toPort="7" fromPort="1" toCard="1" fromCard="1"/>
        <infraRsAccBaseGrp tDn="uni/infra/funcprof/accportgrp-copp"/>
      </infraHPortS>
    </infraAccPortP>

    <infraFuncP>
      <infraAccPortGrp name="copp">
        <infraRsCoppIfPol tnCoppIfPolName="pc"/>
      </infraAccPortGrp>
    </infraFuncP>

    <coppIfPol name = "pc" >
      <coppProtoClassP name = "test" matchProto="lldp,arp" rate="505" burst = "201"/>
      <coppProtoClassP name = "test1" matchProto="bgp" rate="500" burst = "200" />
    </coppIfPol>
```

```
</infraInfra>  
</polUni>
```

## About CoPP Prefilters

In Cisco Application Centric Infrastructure (ACI), you can use the control plane policing (CoPP) prefilter feature to filter control packets sent to the CPU. A CoPP prefilter is the same as an infrastructure access control list (iACL).

Before you use this feature, keep in mind the following key points:

1. This feature works leaf switch-wise or spine switch-wise, not per interface, nor per-L3Out.
2. This feature takes effect across VRF instances, meaning that the filters that you define are not specific to a VRF instance. If you enable a CoPP prefilter and you do not specifically allow ICMP traffic in the configuration of the CoPP prefilter, ICMP traffic sent to the bridge domains of any VRF instance of a given leaf switch is dropped.
3. A CoPP prefilter is configured as a permit-list.
4. This feature is activated by entering the first filtering rule. This means that if you do not have any filtering rules configured, everything is allowed. As soon as you enter the first rule, then everything else is dropped except the traffic that you allow in the filtering rules. This means that all the IPv4/IPv6 control plane traffic by default is denied unless you add it to the permit-list.
5. The filter configuration allows you to enter protocols/DIP/SIP/Protocol/L4 port/L4 port range. You can enter the source and destination IP address of the traffic.
6. You must also allow underlay protocols that are not implicitly allowed. For example, you must allow BGP, otherwise the infra BGP sessions to the leaf or spine switch go down. As another example, you must allow OSPF for remote leaf reachability if you enable this feature on the remote leaf switch.
7. Because of point #6, if you configure a CoPP prefilter on leaf or spine switches of a single POD, you must make sure BGP and DHCP traffic is allowed. If the spine switch is also connected to an IPN/ISN, you must consider allowing OSPF.
8. Because of point #6, in Cisco ACI Multi-Pod, Cisco ACI Multi-Site or Cisco Nexus Dashboard Orchestrator, GOLF, or a remote leaf switch, you must add BGP, DHCP, and OSPF to the permit-list for infra connectivity.
9. Enabling the feature does not disconnect the leaf switch from the fabric because Cisco Application Policy Infrastructure Controller (APIC) traffic is automatically allowed. But, be aware that unless you specifically add BGP to the permit-listed, enabling this feature disconnects the infra BGP session to the leaf switch.
10. The following things are automatically allowed: COOP traffic, vPC control plane traffic, protocols such as LACP/LLDP/CDP, ARP, and Neighbour Discovery packets (RS/RA/NS/NA).
11. ICMP, IGMP, and any other protocol must be specifically allowed. If you enable a CoPP prefilter and you want to make sure that servers can ping the bridge domain subnet IP address, you must make sure ICMP is allowed.

12. There is no support for an ICMP sub-type to allow only ICMP replies or requests. Enabling ICMP enables both.

## Supported Platforms

This section lists the supported platforms for the CoPP prefilter feature.

### Supported leaf switches:

- N9K-C93108TC-EX
- N9K-C93108TC-FX
- N9K-C93108YC-FX
- N9K-C93180LC-EX
- N9K-C93180YC-EX
- N9K-C9348GC-FXP

### Supported spine switches:

- N9K-C92300YC
- N9K-C92304QC
- N9K-C9232C
- N9K-C9236C
- N9K-C9272Q
- N9K-C9364C
- N9K-C9508-FM-2
- N9K-C9516-FM-E2

## Limitations

- Only Ethernet type IPv4 or IPv6 packets can be matched in the egress TCAM. ARP and ND packets are not matched.
- A total of 128 (wide key) entries can be included in the allowed list. However, some entries are reserved for internal use.

## Configuring a CoPP Prefilter, Policy Group, and Profile Using the GUI

### Configuring a CoPP Prefilter Using the Cisco APIC GUI

This section explains how to configure a CoPP prefilter at the leaf level and the spine level using the Cisco APIC GUI.

**Before you begin**

Access to the APIC GUI

**Procedure**

- 
- Step 1** Click **Fabric > External Access Policies**.
- Step 2** From the **Navigation** pane, click **Policies > Switch**.  
The **CoPP Pre-Filter for Leaf** and **CoPP Pre-Filter for Spine** nodes appear in the **Navigation** pane.
- Step 3** From the **Navigation** pane, choose between the following options:
- **CoPP Pre-Filter for Leaf**—To create a CoPP prefilter for a leaf switch, right-click on **CoPP Pre-Filter for Leaf** and choose **Create Profiles for CoPP Pre-Filter To Be Applied At The Leaf Level**.
  - **CoPP Pre-Filter for Spine**—To create a CoPP prefilter for a spine switch, right-click on **CoPP Pre-Filter for Spine** and choose **Create Profiles for CoPP Pre-Filter To Be Applied At The Spine Level**.
- The respective CoPP prefilter dialog appears.
- Step 4** Enter the appropriate values in the dialog fields.
- Note** For information about the fields in the dialog, click the help icon to display the Cisco APIC help file.
- Step 5** When finished, click **Submit**.
- 

**What to do next**

Configure a policy group.

## Configuring a Leaf Policy Group Using the GUI

This section explains how to create a policy group.

**Before you begin**

Access to a Cisco APIC GUI.

**Procedure**

- 
- Step 1** Click **Fabric > External Access Policies**.
- Step 2** From the **Navigation** pane, click **Switches > Leaf Switches**.  
The **Policy Groups** node appears in the **Navigation** pane.
- Step 3** From the **Navigation** pane, **Policy Groups**—To create a leaf policy group, right-click on **Policy Groups** and choose **Create Access Switch Policy Group**.  
The respective policy group dialog appears.

**Step 4** From the policy group dialog, enter a name in the **Name** field and click the drop-down arrow of the policy type you want to apply. Any configured policies for the chosen policy type will appear in the drop-down list.

**Note** For information about the fields in the dialog, click the help icon to display the Cisco APIC help file.

**Step 5** When finished, click **Submit**.

---

#### What to do next

Configure a profile.

## Configuring a Leaf Profile Using the GUI

This section explains how to create a profile.

#### Before you begin

You should have a configured policy group.

#### Procedure

---

**Step 1** Click **Fabric > External Access Policies**.

**Step 2** From the **Navigation** pane, click **Switches > Leaf Switches > Profiles**.  
The **Leaf Profiles** node appears in the **Navigation** pane.

**Step 3** From the **Navigation** pane, **Profiles**—To create a profile for a leaf switch, right-click on **Profiles** and choose **Create Leaf Profile**.

The respective profile dialog appears.

**Step 4** From the profile dialog, enter a name in the **Name** field and click the + to enter the selector information. Click **Update** when finished.

After clicking **Update**, you return to the profile dialog.

**Step 5** Click **Next** to enter the interface selector profile information.

**Note** For information about the fields in the dialog, click the help icon to display the Cisco APIC help file.

**Step 6** When finished, click **Finish**.

---

## Configuring a CoPP Prefilter Using the CLI

### Configuring the CoPP Prefilter for a Leaf Switch Using the CLI

This section explains how to configure a CoPP prefilter policy and policy group then associate a switch policy group with a switch profile using the CLI.

### Procedure

---

- Step 1** Switch# **configure terminal**  
Enters global configuration mode.
- Step 2** Switch(config)# **template control-plane-policing-prefilter-leaf** <name>  
Creates a CoPP prefilter profile for a leaf switch.
- Step 3** Switch (config-control-plane-policing-prefilter-leaf)# **permit proto** { tcp | udp | eigrp | unspecified | icmp | icmpv6 | egp | igp | l2tp | ospf | pim }  
Permits the specified IP protocol.
- Step 4** Switch (config-control-plane-policing-prefilter-leaf)#**exit**  
Enters global configuration mode.
- Step 5** Switch(config)# **template leaf-policy-group** <name>  
Creates a CoPP prefilter policy group leaf switches.
- Step 6** Switch(config-leaf-policy-group)# **control-plane-policing-prefilter** <name>  
Associates a leaf policy group with the CoPP prefilter policy.
- Step 7** Switch(config-leaf-policy-group)# **exit** <name>  
Enters global configuration mode.
- Step 8** Switch(config)# **leaf-profile** <name>  
Creates a leaf profile.
- Step 9** Switch(config-leaf-profile)# **leaf-group** <name>  
Associates a leaf group with a leaf profile.
- Step 10** Switch(config-leaf-group)# **leaf-policy-group** <name>  
Associates a leaf policy group with a leaf group.
- 

## Configuring the CoPP Prefilter for a Spine Switch Using the CLI

This section explains how to configure a CoPP prefilter policy and policy group then associate a switch policy group with a switch profile using the CLI.

### Procedure

---

- Step 1** Switch# **configure terminal**  
Enters global configuration mode.
- Step 2** Switch(config)# **template control-plane-policing-prefilter-spine** <name>

- Creates a CoPP prefilter profile for a spine switch.
- Step 3** Switch (config-control-plane-policing-prefilter-spine)# **permit proto** { **tcp** | **udp** | **eigrp** | **unspecified** | **icmp** | **icmpv6** | **egp** | **igp** | **l2tp** | **ospf** | **pim** }
- Permits the specified IP protocol.
- Step 4** Switch (config-control-plane-policing-prefilter-spine)#**exit**
- Enters global configuration mode.
- Step 5** Switch(config)# **template spine-policy-group** <name>
- Creates a CoPP prefilter policy group spine switches.
- Step 6** Switch(config-spine-policy-group)# **control-plane-policing-prefilter** <name>
- Associates a spine policy group with the CoPP prefilter policy.
- Step 7** Switch(config-spine-policy-group)# **exit** <name>
- Enters global configuration mode.
- Step 8** Switch(config)# **spine-profile** <name>
- Creates a spine profile.
- Step 9** Switch(config-spine-profile)# **spine-group** <name>
- Associates a spine group with a spine profile.
- Step 10** Switch(config-spine-group)# **spine-policy-group** <name>
- Associates a spine policy group with a spine group.

## Configuring a CoPP Prefilter Using the REST API

### Configuring a CoPP Prefilter Policy for a Leaf Switch Using the REST API

This section explains how to configure a CoPP prefilter policy for a leaf switch using the REST API.

#### Procedure

- Step 1** Create a switch policy for CoPP Prefilter with entries the allowed list.

```
<iaclLeafProfile descr="" dn="uni/infra/iaclspinep-spine_icmp" name="COPP_PreFilter_BGP_Config"
  ownerKey="" ownerTag="">
<iaclEntry dstAddr="0.0.0.0/0" dstPortFrom="179" dstPortTo="179" ipProto="tcp" name="bgp"
  nameAlias="" srcAddr="0.0.0.0/0" srcPortFrom="179" srcPortTo="179"/>
</iaclLeafProfile>
```

- Step 2** Create a switch policy group with CoPP prefilter policies.

```
<infraAccNodePGrp descr="" dn="uni/infra/funcprof/accnodepgrp-COPP_PreFilter_BGP_Config "
```



```
name="COPP_PreFilter_BGP_Config" nameAlias="" ownerKey="" ownerTag="">
<infraRsIaclLeafProfile tnIaclLeafProfileName="COPP_PreFilter_BGP_Config"/>
</infraAccNodePGrp>
```

**Step 3** Associate switch policy group to switch profiles.

```
<infraNodeP descr="" dn="uni/infra/nprof-leafP-103" name="leafP-103" nameAlias="" ownerKey=""
ownerTag="">
<infraLeafS descr="" name="103_Sel" nameAlias="" ownerKey="" ownerTag="" type="range">
<infraRsAccNodePGrp tDn="uni/infra/funcprof/accnodegrp-COPP_PreFilter_BGP_Config"/>
<infraNodeBlk descr="" from_"103" name="nblk1" nameAlias="" to_"103"/>
</infraLeafS>
</infraNodeP>
```

## Configuring a CoPP Prefilter Policy for a Spine Using the REST API

This section explains how to configure a CoPP prefilter policy for a spine switch using the REST API.

### Procedure

**Step 1** Create a switch policy for CoPP Prefilter with entries the allowed list.

```
<iacISpineProfile descr="" dn="uni/infra/iacISpineP-spine_icmp"
name="COPP_PreFilter_OSPF_Config" ownerKey="" ownerTag="">
<iacIEntry dstAddr="0.0.0.0/0" dstPortFrom="unspecified" dstPortTo="unspecified"
ipProto="ospfigp" name="" nameAlias="" srcAddr="0.0.0.0/0" srcPortFrom="unspecified"
srcPortTo="unspecified"/>
</iacISpineProfile>
```

**Step 2** Create a switch policy group with CoPP prefilter policies.

```
<infraSpineAccNodePGrp descr=""
dn="uni/infra/funcprof/spaccnodegrp-COPP_PreFilter_OSPF_Config"
name="COPP_PreFilter_OSPF_Config" nameAlias="" ownerKey="" ownerTag="">
<infraRsIacISpineProfile tnIacISpineProfileName="COPP_PreFilter_OSPF_Config"/>
</infraSpineAccNodePGrp>
```

**Step 3** Associate switch policy group to switch profiles.

```
<infraSpineP descr="" dn="uni/infra/spprof-204" name="204" nameAlias="" ownerKey=""
ownerTag="">
<infraSpineS descr="" name="204" nameAlias="" ownerKey="" ownerTag="" type="range">
<infraRsSpineAccNodePGrp tDn="uni/infra/funcprof/spaccnodegrp-COPP_PreFilter_OSPF_Config"/>
<infraNodeBlk descr="" from_"204" name="nodeblock1" nameAlias="" to_"204"/>
</infraSpineS>
<infraRsSpAccPortP tDn="uni/infra/spaccportprof-204"/>
</infraSpineP>
```

### What to do next





# CHAPTER 11

## Fabric Security

---

This chapter contains the following sections:

- [About Federal Information Processing Standards \(FIPS\), on page 143](#)
- [Guidelines and Limitations for FIPS, on page 143](#)
- [Configuring FIPS for Cisco APIC Using the GUI, on page 144](#)
- [Configuring FIPS for Cisco APIC Using the NX-OS Style CLI, on page 144](#)
- [Configuring FIPS for Cisco APIC Using REST API, on page 145](#)

### About Federal Information Processing Standards (FIPS)

The Federal Information Processing Standards (FIPS) Publication 140-2, Security Requirements for Cryptographic Modules, details the U.S. government requirements for cryptographic modules. FIPS 140-2 specifies that a cryptographic module should be a set of hardware, software, firmware, or some combination that implements cryptographic functions or processes, including cryptographic algorithms and, optionally, key generation, and is contained within a defined cryptographic boundary.

FIPS specifies certain cryptographic algorithms as secure, and it also identifies which algorithms should be used if a cryptographic module is to be called FIPS compliant.

### Guidelines and Limitations for FIPS

The following guidelines and limitations apply to FIPS:

- When FIPS is enabled, FIPS is applied across the Cisco Application Policy Infrastructure Controller (APIC).
- When FIPS is enabled, you must disable FIPS before you downgrade the Cisco APIC to a release that does not support FIPS.
- Make your passwords a minimum of eight characters in length.
- Disable Telnet. Log in using only SSH.
- Delete all SSH Server RSA1 keypairs.
- Secure Shell (SSH) and SNMP are supported.

- Disable SNMP v1 and v2. Any existing user accounts on the switch that have been configured for SNMPv3 should be configured only with SHA for authentication and AES for privacy.
- Disable remote authentication through RADIUS/TACACS+. Only local and LDAP users can be authenticated.
- After enabling FIPS on the Cisco APIC, reload the dual supervisor spine switches twice for FIPS to take effect.
- On a dual supervisor spine switch that has FIPS enabled, if a supervisor is replaced, then the spine switch must be reloaded twice for FIPS to take effect on the new supervisor.
- Starting with the 2.3(1) release, FIPS can be configured at the switch level.
- Starting with the 3.1(1) release, when FIPS is enabled, NTP will operate in FIPS mode, Under FIPS mode NTP supports authentication with HMAC-SHA1 and no authentication.

## Configuring FIPS for Cisco APIC Using the GUI

When FIPS is enabled, it is applied across Cisco APIC.

### Procedure

- 
- Step 1** On the menu bar, choose **Admin > AAA**.
- Step 2** In the **Navigation** pane, expand **AAA > Fabric Security**.
- Step 3** In the **Work** pane, in the **Properties** area, choose the desired FIPS mode.

The options for FIPS mode are **Disable** and **Enable**. The default value is Disable.

**Note** You must reboot to complete the configuration. Anytime you change the mode, you must reboot to complete the configuration.

---

## Configuring FIPS for Cisco APIC Using the NX-OS Style CLI

When FIPS is enabled, it is applied across Cisco Application Policy Infrastructure Controller (APIC).

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	Enter the configuration mode.  <b>Example:</b> apic1# <b>configure</b>	

	Command or Action	Purpose
<b>Step 2</b>	Enable FIPS. <b>Example:</b> <code>apic1(config)# fips mode enable</code>	You must reboot to complete the configuration. Anytime you change the mode, you must reboot to complete the configuration.  The <b>no fips mode enable</b> command disables FIPS.

## Configuring FIPS for Cisco APIC Using REST API

When FIPS is enabled, it is applied across Cisco APIC.

### Procedure

---

Configure FIPS for all tenants.

#### Example:

```
https://apic1.cisco.com/api/node/mo/uni/userext.xml  
<aaaFabricSec fipsMode="enable" />
```

**Note** You must reboot to complete the configuration. Anytime you change the mode, you must reboot to complete the configuration.

---





## CHAPTER 12

# Endpoint Security Groups

---

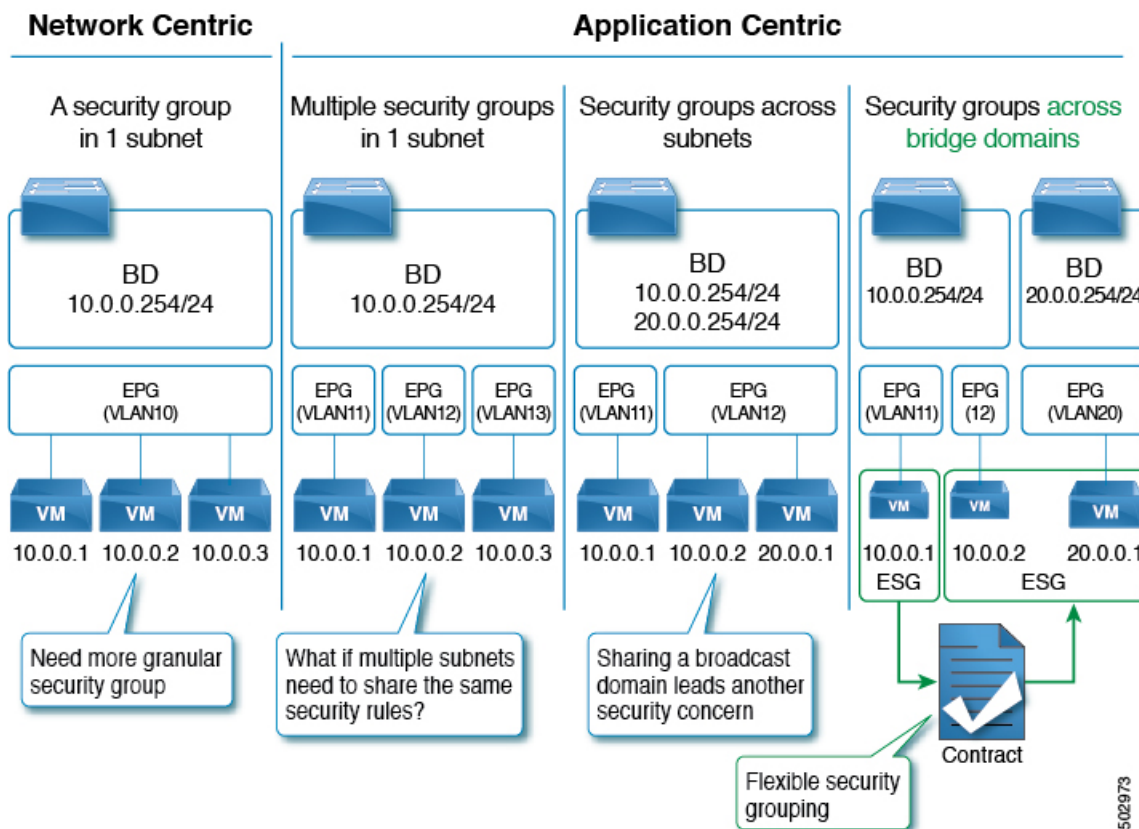
This chapter contains the following topic:

- [Endpoint Security Groups, on page 147](#)
- [Contracts, on page 151](#)
- [ESG Shared Service \(ESG VRF route leaking\), on page 153](#)
- [Layer 4 to Layer 7 Services, on page 155](#)
- [Operational Tools, on page 156](#)
- [Limitations , on page 156](#)
- [ESG Migration Strategy, on page 158](#)
- [Configuring Endpoint Security Groups, on page 161](#)

## Endpoint Security Groups

Endpoint Security Groups (ESGs) are the new network security component in Cisco Application Centric Infrastructure (Cisco ACI). Although the endpoint groups (EPGs) have been providing the network security in Cisco ACI, EPGs have to be associated to a single bridge domain (BD) and used to define security zones within a BD. This is because the EPGs define both forwarding and security segmentation at the same time. The direct relationship between the BD and an EPG limits the possibility of an EPG to spanning more than one BD. This limitation of EPGs is resolved by using the new ESG constructs.

Figure 6: Cisco ACI offers multiple segmentation options



The Application endpoint group (fvAEPg) object that represents an EPG has a direct relationship with the bridge domain object (fvBD) that represents the Layer 2 broadcast domain. This is illustrated in the above figure, in the first three columns.

An ESG is a logical entity that contains a collection of physical or virtual network endpoints. In addition, an ESG is associated to a single VRF (Virtual Routing and Forwarding) instead of BD. This allows the definition of a security zone that is independent of the BDs (the fourth column of *Figure 1*, illustrates this point). Just as the EPGs divide a BD into security zones, the ESGs divide the VRF into security zones.

The EPG policy embeds both forwarding and security logic. For example, an EPG provides not only a security zone based on VLAN, but also a VLAN binding on leaf node interfaces. Also, a contract on the EPG is used to enforce the security and determine which leaf nodes the BD subnet should be deployed on, and which subnets to be leaked to which VRF in the case of VRF route leaking (i.e. shared service). On the contrary, an ESG is used only to enforce security using the contracts while the forwarding logics are handled by other components. With an ESG, the routing logic such as BD subnets deployment and VRF route leaking are moved to VRF level. The VLAN binding on leaf node interfaces are still handled at EPG level.

An ESG is a security construct that has certain match criteria to define which endpoint belongs to the ESG, and uses contracts or policies to define the security stance. The match criteria are called the ESG selectors that are based on attributes, such as an IPv4 or IPv6 address spanning across BDs in the associated VRF. For Cisco APIC, release 5.0(1), the available matching criteria is the IP address or the subnet of an endpoint.

The contract usage in the ESGs is the same as the EPGs. Endpoints that belong to the same ESG can communicate without the need for a contract. To enable communication between endpoints that belong to different ESGs, you need to configure contracts between the ESGs. For the communication with devices

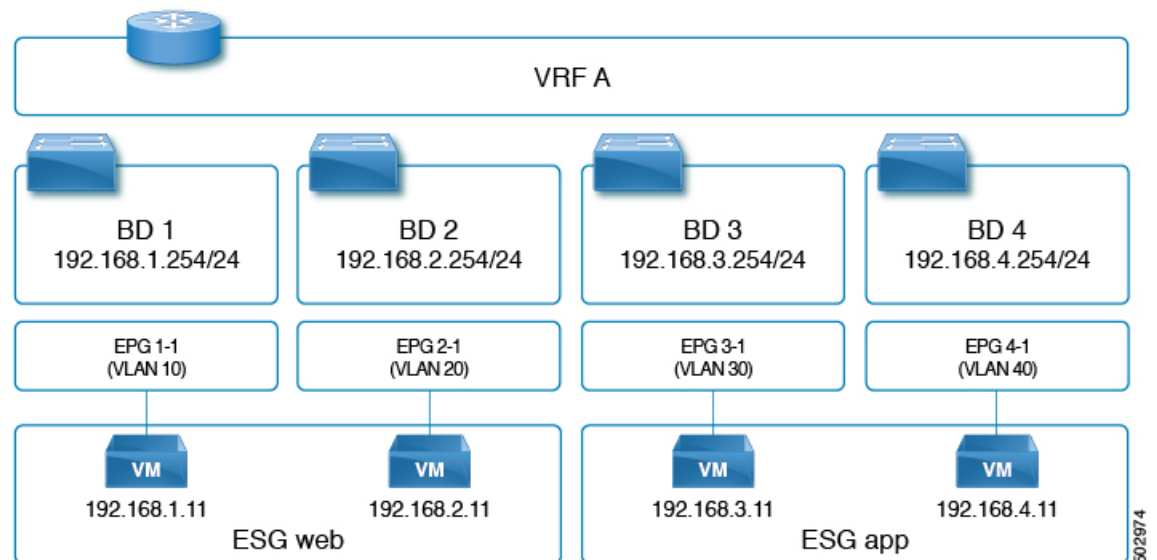


outside of the Cisco ACI fabric, you need to configure a contract between the L3Out external EPG (`l3extInstP`) and the ESG. You can also use a Layer 4 to Layer 7 service graph in conjunction with a contract between the ESGs. However, contracts between an EPG and an ESG are not supported.

## Traffic Filtering from ESG to ESG

In the figure below, there are four bridge domains associated with one EPG each. The administrator uses the EPG configuration to ensure that traffic from virtual machines or from physical servers is associated with the appropriate bridge domain connected to the appropriate VLAN. For instance EPG1-1 defines the mapping of the traffic from VLAN 10 with BD1, the EPG2-1 maps VLAN 20 to BD2, and so on.

**Figure 7: ESGs can be used to aggregate endpoints of different subnets**



- 192.168.1.11 on VLAN 10 and 192.168.2.11 on VLAN 20 belong to different subnets and different bridge domains.
- The administrator defines 192.168.1.11 and 192.168.2.11 as belonging to the same ESG.
- Similarly, 192.168.3.11 and 192.168.4.11 are associated to BD3 and BD4 (via EPG3-1 and EPG4-1) respectively, and they both belong to the same ESG.
- With the above configuration, 192.168.1.11 can freely communicate with 192.168.2.11.
- Similarly, 192.168.3.11 can communicate with 192.168.4.11. However, 192.168.1.11 (or 192.168.2.11) cannot communicate with either 192.168.3.11 or 192.168.4.11 without a contract.

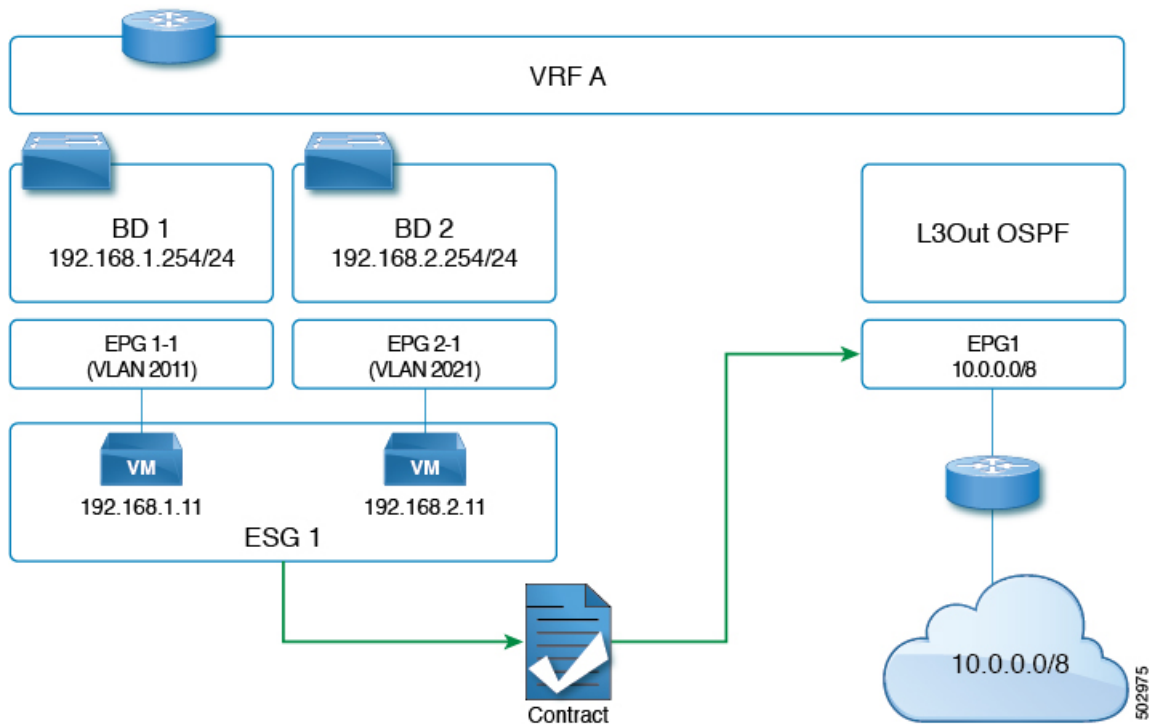


**Note** The contracts that are used by the EPGs cannot be re-used by the ESGs, and vice versa.

## Traffic Filtering from Outside to ESG

The configuration to allow outside to ESG communication is performed by a contract between an L3Out external EPG (L3extInstP) and the ESG as illustrated in the figure below. From the L3Out perspective, there is nothing different between contracts with the ESGs and contracts with the EPGs.

**Figure 8: ESG to outside connectivity is implemented using the L3 External EPG**



## ESG Implementation

This section summarizes how the Cisco Application Policy Infrastructure Controller (APIC) programs leaf nodes, when an administrator configures the ESGs.

- Each ESG is associated with a VRF instance, and the ESG selectors define which endpoints within the VRF instance belongs to the ESG.
- The VRF instance (where an ESG is configured) can be configured either in ingress or egress policy enforcement mode.
- Cisco ACI instantiates the ESG configuration on all of the leaf nodes where the associated VRF instance is deployed.
- When an ESG is configured, all of the BD subnets in the associated VRF instance are present as static routes to the spine proxy on all of the leaf nodes where that VRF instance is present.
- ESGs are always deployed with the deployment immediacy of on-demand, and the associated contract rules are programmed only after an endpoint that matches the ESG selectors are learned on the given leaf node.

- The contracts between ESGs are programmed as policy-cam rules in the leaf node TCAM just as with the EPGs.
- The class-id used by the ESG is a global pcTag.
- Unlike the EPGs, contracts between ESGs create only security rules. ESGs are not used for network deployment such as subnet deployment, or route leaking.
- Even when ESGs are used for security enforcement instead of EPGs, EPGs are still required to configure VLAN bindings on leaf node interfaces.



---

**Note** Cisco APIC generates a unique number to identify each ESG, just as it does for EPGs. This number is called a pcTag or class-id.

Local pcTags are numbers that are unique within a VRF scope, which means that Cisco APIC can generate the same number to identify another EPG in a different VRF instance.

Global pcTags are numbers that are unique in the entire fabric regardless of which VRF instance the ESG (or EPG) belongs to. ESGs are always assigned a global pcTag.

---

## Contracts

Contracts are the Cisco ACI equivalent of access control lists (ACLs). ESGs can only communicate with other ESGs according to the contract rules. The administrator uses a contract to select the types of traffic that can pass between ESGs, including the protocols and ports allowed. An ESG can be a provider, consumer, or both provider and consumer of a contract, and can consume multiple contracts simultaneously. ESGs can also be part of a preferred group so that multiple ESGs can talk freely with other ESGs that are part of the preferred group.

Supported Contracts relationship:

1. ESG ↔ ESG
2. ESG ↔ L3Out EPG
3. ESG ↔ inband-EPG
4. ESG ↔ vzAny

Contracts between the ESGs and the EPGs (or uSeg EPGs) are not supported. When an endpoint in an ESG needs to communicate with other endpoints in the EPG, the other endpoints need to be migrated to the ESGs first. vzAny or preferred group can be used as an alternative during the migration. Other contract-related features that are supported in a uSeg EPG, such as contract inheritance, an intra ESG contract, or intra ESG isolation, are also supported in an ESG. The exception is the Taboo Contract, which is not supported in an ESG.

## vzAny

In alternative to using specific contracts between ESGs, you can also allow traffic between ESGs using a construct called vzAny.

vzAny represents all of the ESGs and EPGs in the given VRF instance. This also includes the L3Out external EPG (`l3extInstP`) within a VRF instance. The vzAny construct provides a shorthand way to refer to all the EPGs and ESGs within that VRF instance. The vzAny referral eases management by allowing for a single point of contract configuration for all EPGs and ESGs within a VRF instance, and optimizes hardware resource consumption by applying the contract to this one group rather than to each EPG or ESG individually.

**Figure 9: vzAny is a shorthand to represent all EPGs and ESGs in the same VRF instance**

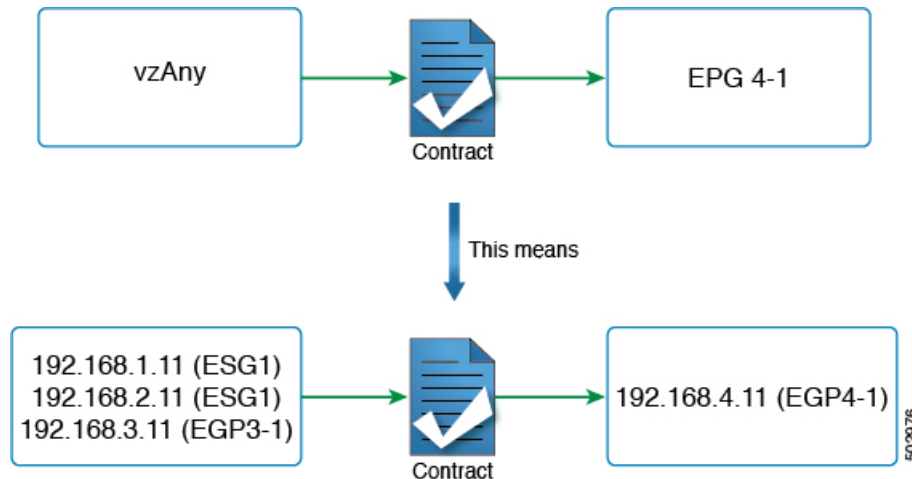


Figure 4 provides an example. If the administrator configures a contract between vzAny and EPG 4-1, in the topology from Figure 2, endpoints 192.168.1.11, 192.168.2.11 (ESG1) and 192.168.3.11 (EPG3-1) can communicate with 192.168.4.11 (EPG4-1).

This does not mean that ESG1 and EPG3-1 belong to the same security zone and 192.168.11 (or 192.168.2.11) can communicate with 192.168.3.11 without a contract. If the desired configuration is to allow any-to-any communication within the VRF instance regardless of an ESG, an EPG, L3Out EPG etc., the user can configure vzAny to provide and consume a contract to allow all traffic instead of disabling **Policy Enforcement (Unenforced)** in the VRF instance.

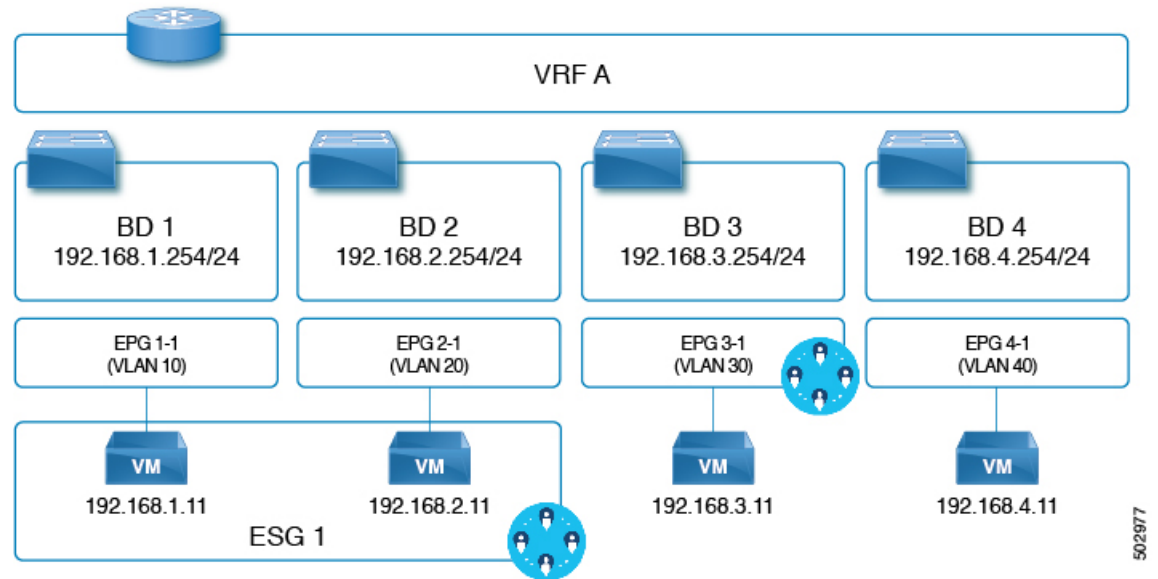
In summary, the vzAny construct can be used for providing and (or) consuming a contract in order to enable an ESG to communicate with anybody in the VRF instance using the contract just as it does for an EPG. Even though the contracts between ESGs and the EPGs are not allowed, vzAny contracts can be used to allow traffic between the ESGs and EPGs.

## Preferred Groups

A preferred group is an alternative to using explicit contracts between ESGs or using vzAny contracts. The user can also configure the preferred group to enable the communication between ESGs in a VRF instance. Any endpoints in the preferred group can communicate with each other freely.

The user can also use preferred groups to enable ESGs to EPGs communication which can be useful in a migration between an EPG-based security configuration to an ESG-based security configuration.

Figure 10: Example with ESG1 and EPG3-1 part of the same preferred group.



In the example of the figure above, ESG1 and EPG3-1 are configured to be part of the preferred group of VRF A and the following communications are allowed:

1. ESG 1 and EPG 3-1 can communicate each other since both are included in the preferred group.
2. ESG 1 and EPG 4-1 cannot communicate each other because:
  - EPG 4-1 is not included in the preferred group.
  - Contracts between EPGs and ESGs are not supported.

Refer to the [Cisco APIC Basic Configuration Guide](#) for information on configuring preferred groups.

## ESG Shared Service (ESG VRF route leaking)

When an endpoint needs a service that is shared by another VRF, there are two things required for the communication to happen. The first thing is the routing reachability. The second thing is security permission. In an EPG, these two are coupled closely in one set of configurations, such as the EPG subnet and contracts. In ESG, these two are decoupled in two different configurations:

1. The configuration of route leaking at the VRF level, which is independent of the ESG contract configuration.
2. The configuration of contracts between the ESGs.

With these two configurations completely decoupled, you do not need to configure a subnet or a subset of the subnet under the ESG as you must do for an EPG.

The following sections explain how to configure route leaking for the bridge domain subnets and external prefixes learned from external routers. After you finish configuring route leaking, you can configure a contract between two ESGs, or an ESG and L3Out EPG, to allow the communication. You must use a contract with a scope larger than VRF, such as global.



**Note** The route leaking configuration at the VRF level is supported only for ESGs.

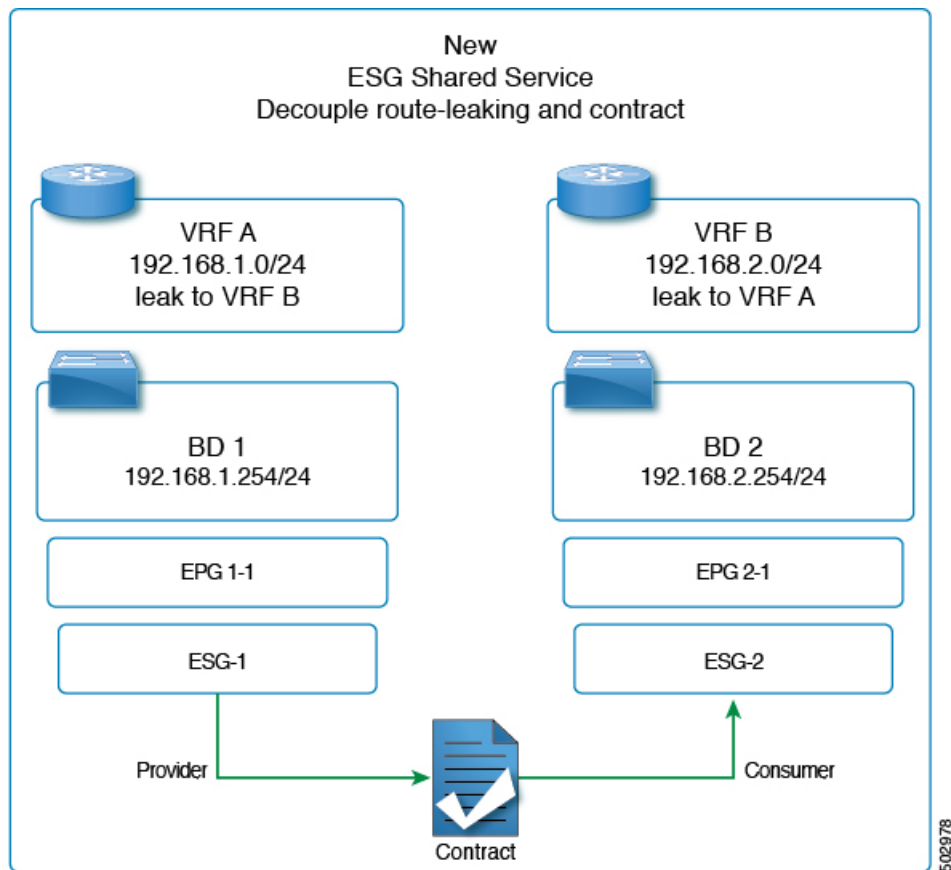
## Route Leaking for Internal Bridge Domain Subnets

This section explains how to configure route leaking between VRF instances for a bridge domain subnet to which the ESG endpoints belong to. This is performed simply by specifying a subnet to leak and the target VRF instance in the source VRF instance at the VRF level (instead of at the EPG level like it is done if you do not use ESGs). The subnet that you enter in the route leaking configuration needs to match the bridge domain subnet or be a subset of a configured bridge domain subnet. The route leaked by this configuration is only the subnet with the specified subnet mask. You cannot specify a range of subnets to leak multiple bridge domain subnets in one configuration.



**Note** The subnet that you configure under the VRF route leaking configuration can also match subnets used under the EPGs. This can be useful for migration purposes.

*Figure 11: Route Leaking with ESGs*



The figure above provides an example of VRF leaking between two VRF instances: VRF A and VRF B, where the administrator has configured two ESGs: ESG1 and ESG2.

In addition to having a contract between ESG1 and ESG2 (to allow the traffic), the administrator needs to configure route leaking in the VRF instance as described in the section, [Configuring Route Leaking of Internal Bridge Domain Subnets using the GUI](#).

The configuration of the bridge domain subnet scopes, **Advertised Externally** and **Shared between VRFs**, is not required with VRF level route leaking for an ESG. When a leaked bridge domain subnet needs to be advertised by L3Outs in the target VRF instance, you can set **Allow L3Out Advertisement** to **True** in the VRF level route leaking configuration. Note that the subnet scopes under a bridge domain are ignored when leaking the subnet to the target VRF instance specified in the VRF level route leaking, and the configuration in the VRF level route leaking takes precedence. Those scopes under a bridge domain are still honored at the same time for other configurations like advertising the subnet from an L3Out in the same VRF instance, route leaking to another VRF instance through a traditional configuration that is through EPG contracts, or both.

## Route Leaking for External Prefixes

The configuration of route leaking for the purpose of allowing traffic from a L3Out of a VRF to ESGs of another VRF is referred to as **ESG shared L3Out** to differentiate from the shared L3Out for EPGs.

In order to leak routes that are learned from a L3Out for an ESG communication, the administrator must configure the route leaking for external prefixes in VRF level. This is done by using IP prefix-list style configuration. The user can configure a specific prefix or can specify a range of prefixes by using the “le” (less than or equal to) or “ge” (greater than or equal to) as you can with an IP prefix-list in a normal router. Unlike bridge domain subnets, there is no restriction that the leaked prefix must be equal to or smaller than an actual route, because external routes are dynamically learned and are not often predictable. Because of the lack of the restriction, a leaked external prefix can specify a range to leak multiple prefixes with one configuration. In the configuration, you must also specify the target VRF.

Please refer to [Configuring Route Leaking of External Prefixes Using the GUI](#) for the configuration details.

For an ESG shared L3Out configuration, along with configuring route leaking in the VRF and applying a contract with L3Out EPG, you need to define which prefix belongs to which L3Out EPG. To specify which prefix belongs to which L3Out EPG, you must configure an L3Out subnet with the **External Subnets for the External EPG** and **Shared Security Import Subnet** scopes.

## Layer 4 to Layer 7 Services

All the Layer 4 to Layer 7 service graph features that are available for the EPGs are supported for the ESGs. The use of service graph between ESGs of different VRFs is not supported in Cisco APIC 5.0.



**Note** This note is an implementation detail for advanced user information. If a service graph is attached to a contract between ESGs, the Cisco APIC automatically creates hidden service EPGs where the Layer 4 to Layer 7 service device attaches, just as Cisco APIC does for a service graph between EPGs. Unlike a service graph between EPGs, in the case of ESGs, the hidden service EPGs get a global pcTag.

Beginning with Cisco APIC release 5.0(1), all new service EPGs that are created for Layer 4 to Layer 7 Service deployments with vzAny-to-vzAny contracts will get global PcTag.

For more information on Layer 4 to Layer 7 services deployment, refer to [Cisco APIC Layer 4 to Layer 7 Services Deployment Guide](#).

## Operational Tools

### Capacity Dashboard

The **Capacity Dashboard** tab can be used to get a summary of critical fabric resource thresholds. This allows you to see quickly how close you are to reaching the approved scalability limits. Per leaf node usage is also shown, allowing you to see quickly which leaf node may be hitting resource constraints.

1. In the menu bar, choose **Operations > Capacity Dashboard** to launch the Capacity Dashboard troubleshooting tool.
2. In the **Capacity Dashboard** page, choose **Fabric Capacity** for the fabric resources. Scroll down for the **Endpoint Security Groups** tile and the **Global pcTag** tile to determine the available resources.
3. In the **Capacity Dashboard** page, choose **Leaf Capacity** for the leaf usage. Check the **ESG** tab for details on the resource usage for Endpoint Security Groups.

### Endpoint Tracker

The **Endpoint Tracker** tab allows you to enter a fabric-attached endpoint IP or MAC address and quickly see the location of this endpoint, the endpoint group to which the endpoint belongs, the VLAN encapsulation used, and if any transitions (flaps) have occurred for this endpoint.

1. In the menu bar, click **Operations > EP Tracker** to launch the Endpoint Tracker troubleshooting tool.
2. In the **End Point Search** field, enter the IP address or MAC address of the endpoint and click **Search**.
3. Click on the endpoint after it is displayed.

The Endpoint Tracker tool displays the date and time of each state transition along with the IP address, MAC address, owning endpoint group, action (attached or detached), physical node, interface, and VLAN encapsulation during the event.

The Endpoint Tracker tool uses an object called the fvCEp to find the endpoints that are learned in the fabric, for an ESG and as well as an EPG. An endpoint that belongs to an ESG is represented by two fvCEp objects, one for the EPG that provides VLAN binding, another for the ESG that provides security. Therefore, the Endpoint Tracker tool shows two entries (one for an EPG, another for an ESG) when used for the ESG endpoints.

## Limitations

As of the Cisco APIC release 5.0(1), the following limitations apply:

- Contracts between ESGs and EPGs are not supported.
- The ESG feature is not integrated with Cisco ACI Multi-Site. Other topologies such as Multi-Pod, Multi-Tier, and Remote Leaf are supported.



- The supported ESG selector is the IP address. MAC addresses, VM tags, or other criteria are not yet supported.
- An ESG contract can be applied only for routed traffic with IP as the selector.
- Taboo contracts are not supported with ESGs.
- Inter-VRF service graphs between ESGs are not supported.
- ESGs are not supported as a source or destination of the following features:
  - On Demand Atomic Counter
  - On Demand Latency Measurement
  - SPAN
- The following features configured at the BD or EPG level are not supported when endpoints in the BD/EPG are classified to an ESG:
  - Endpoint Reachability (Static routes on BD/EPG)
  - Anycast Service
  - Microsoft NLB
  - First Hop Security (FHS)
  - Host Based Routing / Host Route Advertisement
- Only the EX and newer generation of leaf nodes are supported for ESG deployment.
- To prevent Layer 2 traffic (that is, non-routed traffic) from bypassing ESG security when IP is used as the selector, enable an intra EPG contract with a permit-all rule, such as the common default contract, on all of the EPGs that provide VLAN-to-interface binding for the ESG endpoints. If all the endpoints in the EPGs are classified to ESGs, you can alternatively enable intra EPG isolation with proxy ARP on the EPGs instead of the intra EPG contract. If the EPG is used only for VMM DVS integration, you can alternately enable the **Allow Micro-Segmentation** option instead of the other two options mentioned above. Either feature forces all communication between ESG endpoints to go through Layer 3 routing.



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**Note** This note explains the differences between an intra EPG contract with a permit-all rule and intra EPG isolation with proxy-ARP. The main purpose of both features is the same, which is to enforce all traffic to be routed on ACI leaf switches by using proxy-ARP. Note that proxy-ARP is enabled implicitly for the EPG when an intra EPG contract is used. The difference is when there are two or more endpoints that don't belong to ESGs but learned in an EPG. With an intra EPG contract with a permit-all rule, such endpoints can still communicate freely within the same EPG due to the permit-all rule. However, with intra EPG isolation with proxy-ARP, such endpoints can no longer communicate even though they are in the same EPG.

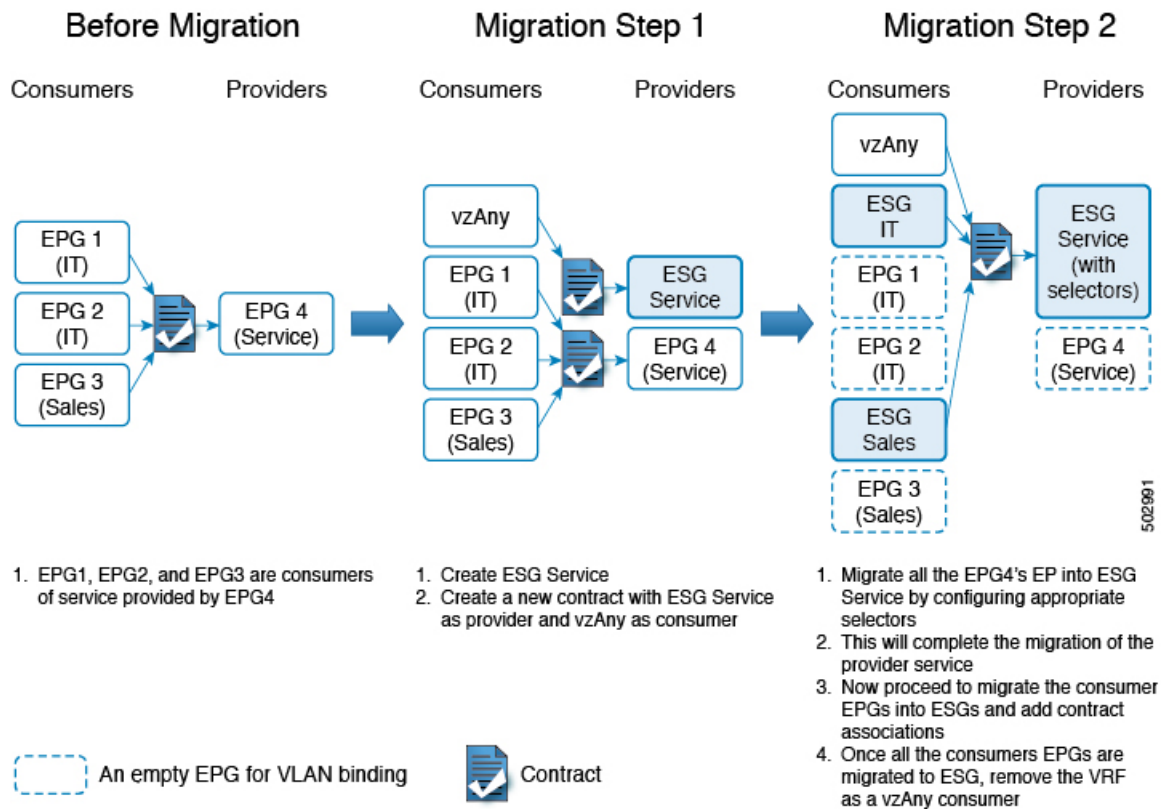
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- Label configurations are not supported when you add contracts to an ESG.

# ESG Migration Strategy

The contracts between an EPG to an ESG are not supported in the Cisco APIC, release 5.0(1). Therefore, to migrate the existing EPG deployments to an ESG with minimal impact, vzAny can be used to allow communication between an EPG and an ESG endpoints during the migration.

**Figure 12: Migration to ESG within VRF**



## For migration to ESG within VRF

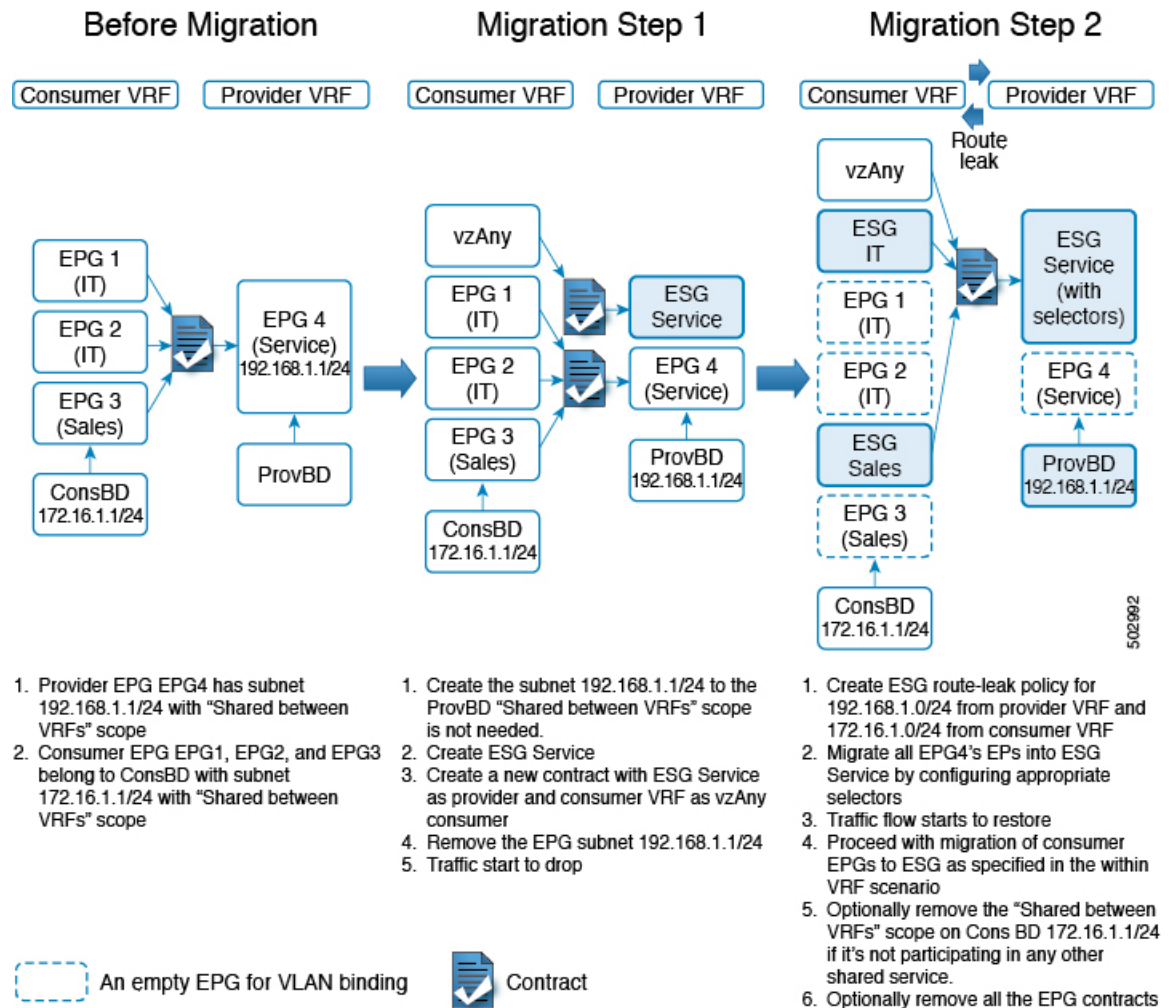
The following procedure explains how to migrate EPGs to ESGs within the same VRF, starting with the provider EPG, EPG4.

1. As shown in the example, firstly create an ESG Service.
2. Configure a new contract, with ESG Service as provider and vzAny as consumer. This will allow the communication between the existing consumer EPG endpoints in EPG1, EPG2 and EPG3 with the newly created ESG service.
3. Now migrate the provider EPG EPG4's endpoints into ESG Service by configuring the appropriate endpoint selectors.
4. This completes the migration of the provider EPG EPG4 to ESG.
5. Prepare the migration of individual consumer EPGs, namely EPG1, EPG2 and EPG3, by creating ESG IT and Sales that consume the same contract as the VRF vzAny.

**Note:** You can alternatively configure fine grain contracts for ESG IT and Sales respectively instead. In such a case, you must provide the new contract from ESG Service as well.

- Now migrate the consumer endpoints to ESGs by configuring the selectors on ESG IT and Sales.
- Once the migration of all the consumer EPGs are completed, the administrator can remove the VRF vzAny consumer configuration.

Figure 13: Migration to ESG across VRF



### For migration to ESG across VRF

For shared services with EPGs, the administrator would have created a subnet under the provider EPG for route leaking across VRFs via contracts. As shown in the above example figure,

- provider EPG EPG4, part of provBD, has subnet 192.168.1.1/24 configured with *Shared between VRFs* scope enabled.
- Consumer EPGs EPG1, EPG2 and EPG3 are part of ConsBD that has subnet 172.16.1.1/24 with *Shared between VRFs* scope enabled.

The following procedure explains how to migrate EPGs to ESGs in the case of shared service, starting with the provider EPG, EPG4.

1. Create the subnet 192.168.1.1/24 on the ProvBD (provider EPG's BD) if not existing already.  
**Note:** *Shared between VRFs* scope is not required.
2. Create a provider ESG Service .
3. Configure a new contract, with ESG Service as the provider and consumer VRF as vzAny consumer. This will allow the communication between the existing consumer EPG endpoints in EPG1, EPG2 and EPG3 with the newly created ESG Service.
4. Remove the EPG4's subnet 192.168.1.1/24 .
5. Once this subnet is removed, the traffic flow across VRF will stop.
6. Proceed with the creation of ESG route-leak policy in the VRF level between provider and consumer VRF. On the consumer VRF leak subnet 172.16.1.0/24 to the provider VRF. On the provider VRF leak subnet 192.168.1.0/24 to the consumer VRF.
7. Now migrate the provider EPG EPG4's endpoints into ESG Service by configuring the appropriate endpoint selectors.
8. Traffic flow across the VRFs will restore. This completes the migration of the provider EPG EPG4 to ESG.
9. Prepare the migration of individual consumer EPGs, namely EPG1, EPG2 and EPG3, by creating ESG IT and Sales that consume the same contract as the VRF vzAny.  
**Note:** You can alternatively configure fine grain contracts for ESG IT and Sales respectively instead. In such a case, you must provide the new contract from ESG Service as well. These contracts (the fine grain or the one consumed by vzAny) need to have a scope larger than VRF such as global.
10. Now migrate the consumer endpoints to ESGs by configuring the selectors on ESG IT and Sales.
11. Optionally, the administration can remove the *Shared between VRFs* scope on the consumer BD subnet 172.16.1.1/24 if this BD is not participating in any other shared service. Also cleanup the EPG contracts association used for shared services.
12. Once the migration of all the consumer EPGs are completed, the administrator can remove the VRF vzAny consumer configuration.

#### Guidelines for EPG shared service and ESG shared service

- If the subnet prefix under the provider EPG is exactly the same as the route leaked via ESG route-leak policy in VRF level, the administrator needs to make sure that the EPG subnet (or shared-service contracts) is deleted prior to configuring the ESG route-leak policy in VRF level. This will prevent overlapping configuration for the same prefix.
- If the subnet prefix under the provider EPG is a subset of the route leaked via ESG route-leak policy in VRF level, the administrator can create the ESG route-leak policy prior to deleting the provider EPG subnet. However, the traffic within the provider EPG subnet will not follow ESG security until the provider EPG subnet is deleted.



**Note** This configuration is valid only when the provider BD has the same subnet as the route leaked via ESG route-leak policy or a subnet larger than that.

- If the subnet prefix under the provider EPG is a superset of the route leaked via ESG route-leak policy in VRF level, the administrator can create the ESG route-leak policy prior to deleting the provider EPG subnet. The traffic within the route leaked via ESG route-leak policy follows the ESG security without deleting the provider EPG subnet.

# Configuring Endpoint Security Groups

## Creating an Endpoint Security Group Using the GUI

### Procedure

- Step 1** On the menu bar, choose **Tenants > All Tenants**. Select the applicable Tenant.  
To create a tenant, refer to [Cisco APIC Basic Configuration Guide, Release 4.2\(x\)](#)
- Step 2** In the Navigation pane, choose **Application Profiles > Endpoint Security Groups**  
To create an application profiles, refer to [Operating Cisco Application Centric Infrastructure](#).
- Step 3** Right click the **Endpoint Security Groups**, and select **create Endpoint Security Group**.
- Step 4** In **Create Endpoint Security Group** page, enter the following information:
  - a) **Name**: Enter the name of the ESG.
  - b) (Optional) **Description**: Enter the description of the ESG.
  - c) **VRF**: Enter the VRF that will be associated with the ESG.
  - d) **Selector**: Click + to add selector. **Create a Selector** page appears. Enter the following information:
    - **Match Expression**: The **key** field is set to **IP** as default; **operator** field is set to **equals** as default. Enter the IP address in the **value** field. For example, the user can enter a specific IP (/32, /128, or without a subnet mask) or a subnet match with any mask length.
    - (Optional) **Description**: Enter the description of the ESG: Enter the description.
    - Click **OK**.
- Step 5** (Optional) In case you need to block communication within the ESG, in the **Intra ESG Isolation** field, choose **Enforced**. The default is **Unenforced**.
- Step 6** (Optional) In case the ESG needs to be in the Preferred Group, in the **Preferred Group Member** field, choose **Include**. The default is **Exclude**.  
When you select **Include**, ensure that the Preferred Group is enabled at the VRF level.  
Refer to [Cisco APIC Basic Configuration Guide](#) for more information on Preferred Groups.

- Step 7** (Optional) In case you need to inherit contracts from another ESG, in the **ESG Contract Master** fields, navigate to the far right and click on the + sign. The user can choose ESGs from which contracts are inherited.
- Step 8** Click **Submit**.

## Applying a Contract to an Endpoint Security Group Using the GUI

### Procedure

- Step 1** On the menu bar, choose **Tenants > ALL TENANTS**. Select the applicable Tenant.
- Step 2** In the Navigation pane expand the **Tenant Name > Application Profiles > Endpoint Security Groups > ESG Name**.
- Step 3** Right click on **Contracts** and choose the action depending on how the contract is to be deployed, such as **Add Provided Contract** or **Add Consumed Contract**.
- Note** A contract that is consumed or provided by an application EPG cannot be used here for an ESG.
- Step 4** In the **Add Contract** dialog box, perform the following actions:
- Enter or select a **Contract Name**.
  - (Optional) Choose a **QOS policy**.
  - (Optional) Choose a **Label**.
- Step 5** Click **Submit**.

## Creating Endpoint Security Groups and Applying a Contract Using the REST API

### Procedure:

```
<polUni>
  <fvTenant name="t0">
    <fvAp name="ap0">
      <!-- ESG with the name ESG1 and Preferred Group as Exclude -->
      <fvESg name="ESG1" prefGrMemb="exclude">
        <!-- The ESG is associated to VRFA -->
        <fvRsScope tnFvCtxName="VRFA" />

        <!-- provided and consumed contracts -->
        <fvRsProv tnVzBrCPName="provided_contract1" />
        <fvRsCons tnVzBrCPName="consumed_contract2" />

        <!-- Endpoint Selectors for the ESG -->
        <fvEPSelector matchExpression="ip=='192.168.0.1/32'" />
        <fvEPSelector matchExpression="ip=='192.168.1.0/28'" />
        <fvEPSelector matchExpression="ip=='2001:23:45::0:0/64'" />
      </fvESg>
    </fvAp>
  </fvTenant>
</polUni>
```

## Configuring Route Leaking of Internal Bridge Domain Subnets using the GUI

Use this procedure to configure route leaking of internal bridge domain subnets.

### Before you begin

You must have created the tenant, VRF, bridge domain, and the subnet to be leaked.

### Procedure

- 
- Step 1** In the Navigation pane, navigate to the **Tenant name > Networking > VRFs > Inter- VRF Leaked Routes for ESG > EPG/BD Subnets**.
- Step 2** Right click on the **EPG/BD Subnets** and select **Configure EPG/BD Subnet to leak**.
- Step 3** In the **Configure EPG/BD Subnet to leak** dialog box, perform the following functions:
- IP**: Enter the bridge domain subnet and its mask to be leaked.
  - (Optional) **Description**: Enter the description of the EPG or bridge domain subnet.
  - (Optional) **Allow L3Out Advertisement**: Set to **True** when this subnet needs to be advertised by L3Outs on another VRF.
- Step 4** In the **Tenant and VRF destinations** field, navigate to the far right and click on the + sign.
- Step 5** In the **Create Tenant and VRF destination** dialog box, perform the following functions:
- Tenant and VRF**: Enter or select the tenant and VRF name.
  - (Optional) **Description**: Enter the description of the destination.
  - Allow L3Out Advertisement**: Set to **True** or **False**, when you need to change the permission per target VRF. By default, this option is set to **inherit** to retain the same configuration as **Allow L3Out Advertisement** in Step 3.
  - Click **OK**.
- Step 6** Click **Submit**.
- 

## Configuring Route Leaking of Internal Bridge Domain Subnets using the REST API

### Before you begin:

You must have configured the BD subnet to be leaked or the BD subnet that includes the leaked subnet.

### Procedure:

```
<polUni>
  <fvTenant name="t0">
    <fvCtx name="VRFA">
      <leakRoutes>
        <!--
          leak the BD subnet 192.168.1.0/24 with the Allow L3Out Advertisement
          False (i.e. scope private)
        -->
      </leakRoutes>
    </fvCtx>
  </fvTenant>
</polUni>
```

```

-->
<leakInternalSubnet ip="192.168.1.0/24" scope="private">
  <!--
    leak the BD subnet to Tenant t1 VRF VRFB with the
    Allow L3Out Advertisement configured in the parent
    scope (i.e. scope inherit)
  -->
  <leakTo ctxName="VRFB" tenantName="t1" scope="inherit" />
</leakInternalSubnet>
</leakRoutes>
</fvCtx>
</fvTenant>
</polUni>

```

## Configuring Route Leaking of External Prefixes Using the GUI

Use this procedure to configure route leaking of external prefixes.

### Before you begin

You must have configured an L3Out in the source VRF and the external prefixes are learned.

### Procedure

- 
- Step 1** In the Navigation pane, navigate to the **Tenant name > Networking > VRFs > Inter- VRF Leaked Routes for ESG > External Prefixes**.
- Step 2** Right click on the **External Prefixes** and select **Create Leaked External Prefix**.
- Step 3** In the **Create Leaked External Prefix** dialog box, perform the following functions:
- IP**: Enter prefix to be leaked.
  - (Optional) **Description**: Enter the description of the leaked external prefix.
  - (Optional) **Greater than or Equal (Prefix)**: Enter the minimum prefix length to be matched. This is equivalent to “ge” in IP prefix-lists in a normal router.
  - (Optional) **Less than or Equal (Prefix)**: Enter the maximum prefix length to be matched. This is equivalent to “le” in IP prefix-lists in a normal router.
- Step 4** In the **Tenant and VRF destinations** field, navigate to the far right and click on the + sign.
- Step 5** In the **Create Tenant and VRF destination** dialog box, perform the following functions:
- Tenant and VRF**: Enter or select the tenant and VRF name.
  - (Optional) **Description**: Enter the description of the destination.
  - Click **OK**.
- Step 6** Click **Submit**.
- 

## Configuring Route Leaking of External Prefixes Using the REST API

### Before you begin:

You must have configured an L3Out in the source VRF “VRFA” and external prefixes are learned.



**Procedure:**

```

<polUni>
  <fvTenant name="t0">
    <fvCtx name="VRFA">
      <leakRoutes>
        <!--
          leak the external prefixes in the range of
          10.20.0.0/17 and 10.20.0.0/30
        -->
        <!--
          leak the external prefixes to Tenant t1 VRF VRFB -->
        <leakTo ctxName="VRFB" tenantName="t1" />
      </leakExternalPrefix>
    </leakRoutes>
  </fvCtx>
</fvTenant>
</polUni>

```

## Applying Layer 4 to Layer 7 Services to an Endpoint Security Group Using the GUI

All the configurations provided for the deployment of a service graph with EPGs equally apply to the ESGs, the only change required is that instead of associating the contract to EPGs the contract is associated to ESGs. Use this procedure to apply a service graph template for a Layer 4 to Layer 7 service device in unmanaged mode to a contract used by endpoint security groups:

**Before you begin**

You must have created the following things:

- ESGs
- A service graph template

**Procedure**

- 
- Step 1** On the menu bar, choose **Tenants > All Tenants**.
  - Step 2** In the Work pane, double click the tenant's name.
  - Step 3** In the Navigation pane, expand **Tenant > Services > L4-L7 > Service Graph Templates**.
  - Step 4** In the Navigation pane, right-click on the **Service Graph Template Name** that you want to apply to the ESGs and choose **Apply L4-L7 Service Graph Template**.

The **Apply L4-L7 Service Graph Template To EPGs** dialog box appears. You will be associating a Layer 4 to Layer 7 service graph template to a contract between the endpoint security groups.

- Step 5** Configure a contract in the **Apply L4-L7 Service Graph Template To EPGs STEP 1> Contract** dialog box by entering the appropriate values:
  - Select **Endpoint Security Group** as the endpoint group type.
  - If you are configuring an intra-ESG contract, place a check in the **Configure an Intra-Endpoint Contract** check-box and choose the ESG from the **ESG / Network** drop-down list.
  - If you are using a normal contract instead of intra-ESG contract, select the ESG and network combination for consumer and provider.

- d) Create a new contract or choose an existing one by clicking the appropriate radio button in the **Contract Type** field. If you select **Create A New Contract** and want to configure the filters for it, remove the check from the **No Filter (Allow All Traffic)** check-box. Click + to add filter entries and **Update** when complete.

**Step 6** Click **Next**.

The **STEP 2 > Graph** dialog appears.

**Step 7** In the **your device name Information** section, configure the required fields represented with a red box.

**Step 8** Click **Finish**.

You now have applied a service graph template to a contract used by ESGs.

**Note** To configure vzAny, select **AnyEPG** as provider and the ESG of interest as consumer, or vice versa in Step 5.c above.

To apply a service graph to a vzAny-to-vzAny contract vzAny-vzAny, select **Endpoint Policy Group (EPG)** as the endpoint group type and select **AnyEPG** as provider and consumer.

---

## Applying Layer 4 to Layer 7 Services to Endpoint Security Groups Using the REST APIs

All the REST API's provided for the deployment of service graph with the EPGs equally apply to ESGs. However, the contract must be associated to the ESGs.

Please refer to [Layer 4 to Layer 7 REST API examples](#) for more information.



# CHAPTER 13

## Security Policies

This chapter contains the following sections:

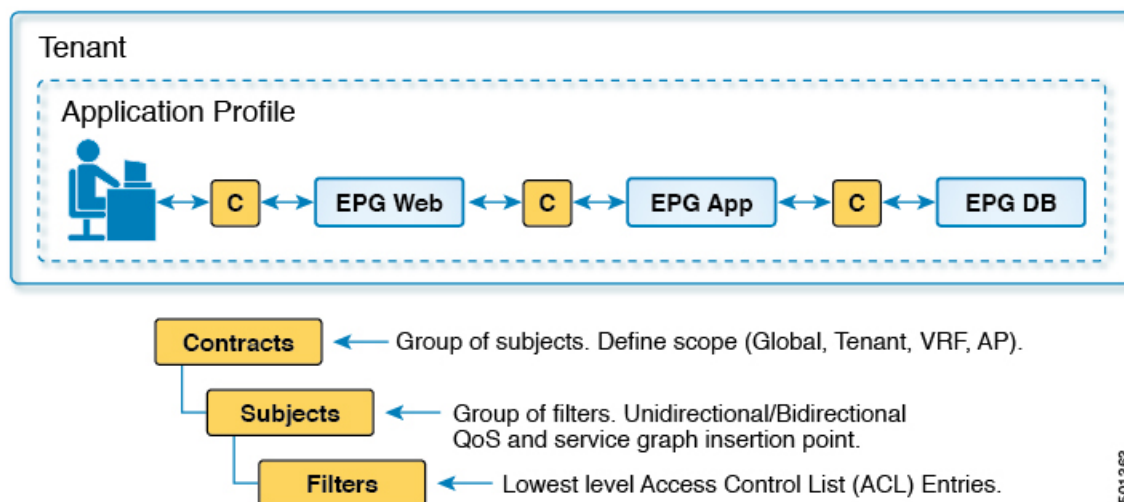
- [ACI Fabric Network Access Security Policy Model \(Contracts\)](#), on page 167
- [Enabling and Viewing ACL Contract and Deny Logs](#), on page 172

### ACI Fabric Network Access Security Policy Model (Contracts)

The ACI fabric security policy model is based on contracts. This approach addresses limitations of traditional access control lists (ACLs). Contracts contain the specifications for security policies that are enforced on traffic between endpoint groups.

The following figure shows the components of a contract.

**Figure 14: Contract Components**



EPG communications require a contract; EPG to EPG communication is not allowed without a contract. The APIC renders the entire policy model, including contracts and their associated EPGs, into the concrete model in each switch. Upon ingress, every packet entering the fabric is marked with the required policy details. Because contracts are required to select what types of traffic can pass between EPGs, contracts enforce security policies. While contracts satisfy the security requirements handled by access control lists (ACLs) in conventional network settings, they are a more flexible, manageable, and comprehensive security policy solution.

## Access Control List Limitations

Traditional access control lists (ACLs) have a number of limitations that the ACI fabric security model addresses. The traditional ACL is very tightly coupled with the network topology. They are typically configured per router or switch ingress and egress interface and are customized to that interface and the traffic that is expected to flow through those interfaces. Due to this customization, they often cannot be reused across interfaces, much less across routers or switches.

Traditional ACLs can be very complicated and cryptic because they contain lists of specific IP addresses, subnets, and protocols that are allowed as well as many that are specifically not allowed. This complexity means that they are difficult to maintain and often simply just grow as administrators are reluctant to remove any ACL rules for fear of creating a problem. Their complexity means that they are generally only deployed at specific demarcation points in the network such as the demarcation between the WAN and the enterprise or the WAN and the data center. In this case, the security benefits of ACLs are not exploited inside the enterprise or for traffic that is contained within the data center.

Another issue is the possible huge increase in the number of entries in a single ACL. Users often want to create an ACL that allows a set of sources to communicate with a set of destinations by using a set of protocols. In the worst case, if  $N$  sources are talking to  $M$  destinations using  $K$  protocols, there might be  $N*M*K$  lines in the ACL. The ACL must list each source that communicates with each destination for each protocol. It does not take many devices or protocols before the ACL gets very large.

The ACI fabric security model addresses these ACL issues. The ACI fabric security model directly expresses the intent of the administrator. Administrators use contract, filter, and label managed objects to specify how groups of endpoints are allowed to communicate. These managed objects are not tied to the topology of the network because they are not applied to a specific interface. They are simply rules that the network must enforce irrespective of where these groups of endpoints are connected. This topology independence means that these managed objects can easily be deployed and reused throughout the data center not just as specific demarcation points.

The ACI fabric security model uses the endpoint grouping construct directly so the idea of allowing groups of servers to communicate with one another is simple. A single rule can allow an arbitrary number of sources to communicate with an equally arbitrary number of destinations. This simplification dramatically improves their scale and maintainability which also means they are easier to use throughout the data center.

## Contracts Contain Security Policy Specifications

In the ACI security model, contracts contain the policies that govern the communication between EPGs. The contract specifies what can be communicated and the EPGs specify the source and destination of the communications. Contracts link EPGs, as shown below.

EPG 1 ----- CONTRACT ----- EPG 2

Endpoints in EPG 1 can communicate with endpoints in EPG 2 and vice versa if the contract allows it. This policy construct is very flexible. There can be many contracts between EPG 1 and EPG 2, there can be more than two EPGs that use a contract, and contracts can be reused across multiple sets of EPGs, and more.

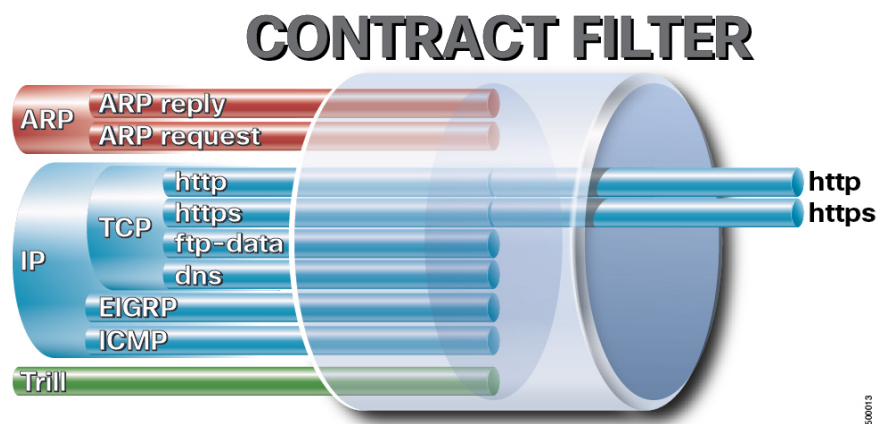
There is also directionality in the relationship between EPGs and contracts. EPGs can either provide or consume a contract. An EPG that provides a contract is typically a set of endpoints that provide a service to a set of client devices. The protocols used by that service are defined in the contract. An EPG that consumes a contract is typically a set of endpoints that are clients of that service. When the client endpoint (consumer) tries to connect to a server endpoint (provider), the contract checks to see if that connection is allowed. Unless otherwise specified, that contract would not allow a server to initiate a connection to a client. However, another contract between the EPGs could easily allow a connection in that direction.

This providing/consuming relationship is typically shown graphically with arrows between the EPGs and the contract. Note the direction of the arrows shown below.

EPG 1 <-----consumes----- CONTRACT <-----provides----- EPG 2

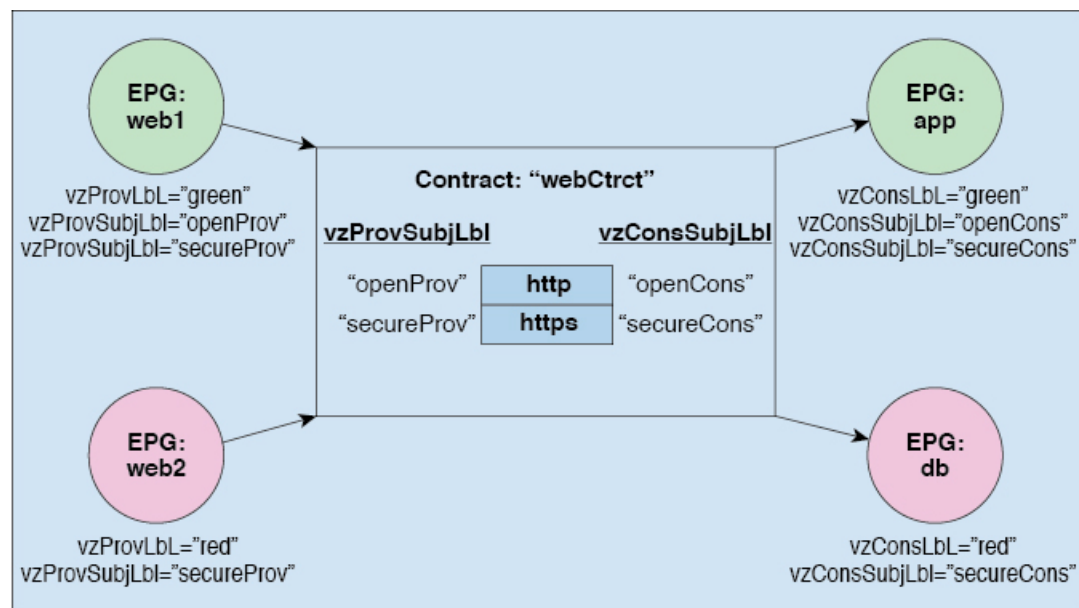
The contract is constructed in a hierarchical manner. It consists of one or more subjects, each subject contains one or more filters, and each filter can define one or more protocols.

Figure 15: Contract Filters



The following figure shows how contracts govern EPG communications.

Figure 16: Contracts Determine EPG to EPG Communications



For example, you may define a filter called HTTP that specifies TCP port 80 and port 8080 and another filter called HTTPS that specifies TCP port 443. You might then create a contract called webCtct that has two sets of subjects. openProv and openCons are the subjects that contain the HTTP filter. secureProv and secureCons are the subjects that contain the HTTPS filter. This webCtct contract can be used to allow both secure and non-secure web traffic between EPGs that provide the web service and EPGs that contain endpoints that want to consume that service.

These same constructs also apply for policies that govern virtual machine hypervisors. When an EPG is placed in a virtual machine manager (VMM) domain, the APIC downloads all of the policies that are associated with the EPG to the leaf switches with interfaces connecting to the VMM domain. For a full explanation of VMM domains, see the *Virtual Machine Manager Domains* chapter of *Application Centric Infrastructure Fundamentals*. When this policy is created, the APIC pushes it (pre-populates it) to a VMM domain that specifies which switches allow connectivity for the endpoints in the EPGs. The VMM domain defines the set of switches and ports that allow endpoints in an EPG to connect to. When an endpoint comes on-line, it is associated with the appropriate EPGs. When it sends a packet, the source EPG and destination EPG are derived from the packet and the policy defined by the corresponding contract is checked to see if the packet is allowed. If yes, the packet is forwarded. If no, the packet is dropped.

Contracts consist of 1 or more subjects. Each subject contains 1 or more filters. Each filter contains 1 or more entries. Each entry is equivalent to a line in an Access Control List (ACL) that is applied on the Leaf switch to which the endpoint within the endpoint group is attached.

In detail, contracts are comprised of the following items:

- Name—All contracts that are consumed by a tenant must have different names (including contracts created under the common tenant or the tenant itself).
- Subjects—A group of filters for a specific application or service.
- Filters—Used to classify traffic based upon layer 2 to layer 4 attributes (such as Ethernet type, protocol type, TCP flags and ports).
- Actions—Action to be taken on the filtered traffic. The following actions are supported:
  - Permit the traffic (regular contracts, only)
  - Mark the traffic (DSCP/CoS) (regular contracts, only)
  - Redirect the traffic (regular contracts, only, through a service graph)
  - Copy the traffic (regular contracts, only, through a service graph or SPAN)
  - Block the traffic (taboo contracts)  
  
With Cisco APIC Release 3.2(x) and switches with names that end in EX or FX, you can alternatively use a subject Deny action or Contract or Subject Exception in a standard contract to block traffic with specified patterns.
  - Log the traffic (taboo contracts and regular contracts)
- Aliases—(Optional) A changeable name for an object. Although the name of an object, once created, cannot be changed, the Alias is a property that can be changed.

Thus, the contract allows more complex actions than just allow or deny. The contract can specify that traffic that matches a given subject can be re-directed to a service, can be copied, or can have its QoS level modified. With pre-population of the access policy in the concrete model, endpoints can move, new ones can come on-line, and communication can occur even if the APIC is off-line or otherwise inaccessible. The APIC is removed from being a single point of failure for the network. Upon packet ingress to the ACI fabric, security policies are enforced by the concrete model running in the switch.

## Security Policy Enforcement

As traffic enters the leaf switch from the front panel interfaces, the packets are marked with the EPG of the source EPG. The leaf switch then performs a forwarding lookup on the packet destination IP address within the tenant space. A hit can result in any of the following scenarios:

1. A unicast (/32) hit provides the EPG of the destination endpoint and either the local interface or the remote leaf switch VTEP IP address where the destination endpoint is present.
2. A unicast hit of a subnet prefix (not /32) provides the EPG of the destination subnet prefix and either the local interface or the remote leaf switch VTEP IP address where the destination subnet prefix is present.
3. A multicast hit provides the local interfaces of local receivers and the outer destination IP address to use in the VXLAN encapsulation across the fabric and the EPG of the multicast group.



---

**Note** Multicast and external router subnets always result in a hit on the ingress leaf switch. Security policy enforcement occurs as soon as the destination EPG is known by the ingress leaf switch.

---

A miss result in the forwarding table causes the packet to be sent to the forwarding proxy in the spine switch. The forwarding proxy then performs a forwarding table lookup. If it is a miss, the packet is dropped. If it is a hit, the packet is sent to the egress leaf switch that contains the destination endpoint. Because the egress leaf switch knows the EPG of the destination, it performs the security policy enforcement. The egress leaf switch must also know the EPG of the packet source. The fabric header enables this process because it carries the EPG from the ingress leaf switch to the egress leaf switch. The spine switch preserves the original EPG in the packet when it performs the forwarding proxy function.

On the egress leaf switch, the source IP address, source VTEP, and source EPG information are stored in the local forwarding table through learning. Because most flows are bidirectional, a return packet populates the forwarding table on both sides of the flow, which enables the traffic to be ingress filtered in both directions.

## Multicast and EPG Security

Multicast traffic introduces an interesting problem. With unicast traffic, the destination EPG is clearly known from examining the packet's destination. However, with multicast traffic, the destination is an abstract entity: the multicast group. Because the source of a packet is never a multicast address, the source EPG is determined in the same manner as in the previous unicast examples. The derivation of the destination group is where multicast differs.

Because multicast groups are somewhat independent of the network topology, static configuration of the (S, G) and (\*, G) to group binding is acceptable. When the multicast group is placed in the forwarding table, the EPG that corresponds to the multicast group is also put in the forwarding table.



---

**Note** This document refers to multicast stream as a multicast group.

---

The leaf switch always views the group that corresponds to the multicast stream as the destination EPG and never the source EPG. In the access control matrix shown previously, the row contents are invalid where the multicast EPG is the source. The traffic is sent to the multicast stream from either the source of the multicast stream or the destination that wants to join the multicast stream. Because the multicast stream must be in the

forwarding table and there is no hierarchical addressing within the stream, multicast traffic is access controlled at the ingress fabric edge. As a result, IPv4 multicast is always enforced as ingress filtering.

The receiver of the multicast stream must first join the multicast stream before it receives traffic. When sending the IGMP Join request, the multicast receiver is actually the source of the IGMP packet. The destination is defined as the multicast group and the destination EPG is retrieved from the forwarding table. At the ingress point where the router receives the IGMP Join request, access control is applied. If the Join request is denied, the receiver does not receive any traffic from that particular multicast stream.

The policy enforcement for multicast EPGs occurs on the ingress by the leaf switch according to contract rules as described earlier. Also, the multicast group to EPG binding is pushed by the APIC to all leaf switches that contain the particular tenant (VRF).

## Taboos

While the normal processes for ensuring security still apply, the ACI policy model aids in assuring the integrity of whatever security practices are employed. In the ACI policy model approach, all communications must conform to these conditions:

- Communication is allowed only based on contracts, which are managed objects in the model. If there is no contract, inter-EPG communication is disabled by default.
- No direct access to the hardware; all interaction is managed through the policy model.

Taboo contracts can be used to deny specific traffic that is otherwise allowed by contracts. The traffic to be dropped matches a pattern (such as, any EPG, a specific EPG, or traffic matching a filter). Taboo rules are unidirectional, denying any matching traffic coming toward an EPG that provides the contract.

With Cisco APIC Release 3.2(x) and switches with names that end in EX or FX, you can alternatively use a subject Deny action or Contract or Subject Exception in a standard contract to block traffic with specified patterns.

# Enabling and Viewing ACL Contract and Deny Logs

## About ACL Contract Permit and Deny Logs

To log and/or monitor the traffic flow for a contract rule, you can enable and view the logging of packets or flows that were allowed to be sent because of contract permit rules or the logging of packets or flows that were dropped because of:

- Taboo contract deny rules
- Deny actions in contract subjects
- Contract or subject exceptions
- ACL contract permit in the ACI fabric is only supported on Nexus 9000 Series switches with names that end in EX or FX, and all later models. For example, N9K-C93180LC-EX or N9K-C9336C-FX.
- Deny logging in the ACI fabric is supported on all platforms.



- Using log directive on filters in management contracts is not supported. Setting the log directive will cause zoning-rule deployment failure.

For information on standard and taboo contracts and subjects, see *Cisco Application Centric Infrastructure Fundamentals* and *Cisco APIC Basic Configuration Guide*.

### EPG Data Included in ACL Permit and Deny Log Output

Up to Cisco APIC, Release 3.2(1), the ACL permit and deny logs did not identify the EPGs associated with the contracts being logged. In release 3.2(1) the source EPG and destination EPG are added to the output of ACL permit and deny logs. ACL permit and deny logs include the relevant EPGs with the following limitations:

- Depending on the position of the EPG in the network, EPG data may not be available for the logs.
- When configuration changes occur, log data may be out of date. In steady state, log data is accurate.

The most accurate EPG data in the permit and deny logs results when the logs are focussed on:

- Flows from EPG to EPG, where the ingress policy is installed at the ingress TOR and the egress policy is installed at the egress TOR.
- Flows from EPG to L3Out, where one policy is applied on the border leaf TOR and the other policy is applied on a non-BL TOR.

EPGs in the log output are not supported for uSeg EPGs or for EPGs used in shared services (including shared L3Outs).

## Enabling ACL Contract Permit and Deny Logging Using the GUI

The following steps show how to enable contract permit and deny logging using the GUI:




---

**Note** The tenant that contains the permit logging is the tenant that contains the VRF that the EPG is associated to. This will not necessarily be the same tenant as the EPG or its associated contracts.

---

### Procedure

- 
- Step 1** On the menu bar, choose **Tenants** > <tenant name>.
- Step 2** In the **Navigation** pane, expand **Contracts**, right-click **Standard**, and choose **Create Contract**.
- Step 3** In the **Create Contract** dialog box, perform the following actions:
- In the **Name** field, type the name for the contract.
  - In the **Scope** field, choose the scope for it (VRF, Tenant, or Global).
  - Optional. Set the target DSCP or QoS class to be applied to the contract.
  - Click the + icon to expand **Subjects**.
- Step 4** In the Create Contract Subject dialog box, perform the following actions:
- Step 5** Enter the name of the subject and an optional description.
- Step 6** Optional. From the drop-down list for the target DSCP, select the DSCP to be applied to the subject.

- Step 7** Leave **Apply Both Directions** checked, unless you want the contract to only be applied from the consumer to the provider, instead of in both directions.
- Step 8** Leave **Reverse Filter Ports** checked if you unchecked **Apply Both Directions** to swap the Layer 4 source and destination ports so that the rule is applied from the provider to the consumer.
- Step 9** Click the + icon to expand **Filters**.
- Step 10** In the **Name** drop-down list, choose an option; for example, click **arp**, **default**, **est**, or **icmp**, or choose a previously configured filter.
- Step 11** In the **Directives** drop-down list, click **log**.
- Step 12** (Optional) Change the Action to be taken with this subject to **Deny** (or leave the action to the default, **Permit**.  
With Directive: log enabled, if the action for this subject is **Permit**, ACL permit logs track the flows and packets that are controlled by the subject and contract. If the action for this subject is **Deny**, ACL deny logs track the flows and packets.
- Step 13** (Optional) Set the priority for the subject.
- Step 14** Click **Update**.
- Step 15** Click **OK**.
- Step 16** Click **Submit**.  
Logging is enabled for this contract.

## Enabling ACL Contract Permit Logging Using the NX-OS CLI

The following example shows how to enable Contract permit logging using the NX-OS CLI.

### Procedure

- Step 1** To enable logging of packets or flows that were allowed to be sent because of Contract permit rules, use the following commands:
- ```
configure
tenant <tenantName>
contract <contractName> type <permit>
subject <subject Name>
access-group <access-list> <in/out/both> log
```
- Example:**
- For example:
- ```
apicl# configure
apicl(config)# tenant BDMoDel
apicl(config-tenant)# contract Logicmp type permit
apicl(config-tenant-contract)# subject icmp
apicl(config-tenant-contract-subj)# access-group arp both log
```
- Step 2** To disable the permit logging use the **no** form of the access-group command; for example, use the **no access-group arp both log** command.

## Enabling ACL Contract Permit Logging Using the REST API

The following example shows you how to enable permit and deny logging using the REST API. This example configures ACL permit and deny logging for a contract with subjects that have Permit and Deny actions configured.

### Procedure

For this configuration, send a post with XML similar to the following example:

#### Example:

```
<vzBrCP dn="uni/tn-Tenant64/brc-C64" name="C64" scope="context">
  <vzSubj consMatchT="AtleastOne" name="HTTPSsbj" provMatchT="AtleastOne" revFltPorts="yes"
    rn="subj-HTTPSsbj">
    <vzRsSubjFiltAtt action="permit" directives="log" forceResolve="yes"
      priorityOverride="default"
      rn="rbsubjFiltAtt-PerHTTPS" tDn="uni/tn-Tenant64/flt-PerHTTPS" tRn="flt-PerHTTPS"
      tnVzFilterName="PerHTTPS"/>
    </vzSubj>
    <vzSubj consMatchT="AtleastOne" name="httpSbj" provMatchT="AtleastOne" revFltPorts="yes"
      rn="subj-httpSbj">
      <vzRsSubjFiltAtt action="deny" directives="log" forceResolve="yes"
        priorityOverride="default"
        rn="rbsubjFiltAtt-httpFilter" tDn="uni/tn-Tenant64/flt-httpFilter" tRn="flt-httpFilter"
        tnVzFilterName="httpFilter"/>
      </vzSubj>
      <vzSubj consMatchT="AtleastOne" name="subj64" provMatchT="AtleastOne" revFltPorts="yes"
        rn="subj-subj64">
          <vzRsSubjFiltAtt action="permit" directives="log" forceResolve="yes"
            priorityOverride="default"
            rn="rbsubjFiltAtt-icmp" tDn="uni/tn-common/flt-icmp" tRn="flt-icmp" tnVzFilterName="icmp"/>
        </vzSubj>
    </vzBrCP>
```

## Enabling Taboo Contract Deny Logging Using the GUI

The following steps show how to enable Taboo Contract deny logging using the GUI.

### Procedure

- Step 1** On the menu bar, choose **Tenants** > <tenant name>.
- Step 2** In the **Navigation** pane, expand **Contracts**.
- Step 3** Right-click **Taboos** and choose **Create Taboo Contract**.
- Step 4** In the Create Taboo Contract dialog box, perform the following actions to specify the Taboo contract:
  - a) In the **Name** field, type the name for the contract.
  - b) Optional. In the **Description** field, type a description of the Taboo contract.
  - c) Click the + icon to expand **Subjects**.
- Step 5** In the **Create Taboo Contract Subject** dialog box, perform the following actions:

- a) In the Specify Identity of Subject area, type a name and optional description.
- b) Click the + icon to expand **Filters**.
- c) From the **Name** drop-down list, choose one of the default values, such as `<tenant_name>/arp`, `<tenant_name>/default`, `<tenant_name>/est`, `<tenant_name>/icmp`, choose a previously created filter, or **Create Filter**.

**Note** If you chose **Create Filter**, in the Specify Filter Identity Area, perform the following actions to specify criteria for the ACL Deny rule:

- a. Type a name and optional description.
- b. Expand **Entries**, type a name for the rule, and choose the criteria to define the traffic you want to deny.
- c. In the Directives drop-down list, choose **log**.
- d. Click **Update**.
- e. Click **OK**.

**Step 6** Click **Submit**.  
Logging is enabled for this Taboo contract.

## Enabling Taboo Contract Deny Logging Using the NX-OS CLI

The following example shows how to enable Taboo Contract deny logging using the NX-OS CLI.

### Procedure

**Step 1** To enable logging of packets or flows dropped because of Taboo Contract deny rules, use the following commands:

```
configure
tenant <tenantName>
contract <contractName> type <deny>
subject <subject Name>
access-group <access-list> <both> log
```

#### Example:

For example:

```
apicl# configure
apicl(config)# tenant BDMoel
apicl(config-tenant)# contract dropFTP type deny
apicl(config-tenant-contract)# subject dropftp
apicl(config-tenant-contract-subj)# access-group ftp both log
```

**Step 2** To disable the deny logging use the **no** form of the access-group command; for example, use the `no access-group https both log` command.

## Enabling Taboo Contract Deny Logging Using the REST API

The following example shows you how to enable Taboo Contract deny logging using the REST API.

### Procedure

To configure taboo contract deny logging, send a post with XML similar to the following example.

#### Example:

```
<vzTaboo dn="uni/tn-Tenant64/taboo-TCtrctPrefix" name="TCtrctPrefix" scope="context">
  <vzTSubj name="PrefSubj" rn="tsubj-PrefSubj">
    <vzRsDenyRule directives="log" forceResolve="yes" rn="rsdenyRule-default"
    tCl="vzFilter"
    tDn="uni/tn-common/flt-default" tRn="flt-default"/>
  </vzTSubj>
</vzTaboo>
```

## Viewing ACL Permit and Deny Logs Using the GUI

The following steps show how to view ACL permit and deny logs (if they are enabled) for traffic flows, using the GUI:

### Procedure

- Step 1** On the menu bar, choose **Tenants** > <tenant name>.
- Step 2** In the **Navigation** pane, click on **Tenant** <tenant name>.
- Step 3** In the **Tenants** <tenant name> **Work** pane, click the **Operational** tab.
- Step 4** Under the **Operational** tab, click the **Flows** tab.  
Under the **Flows** tab, click one of the tabs to view log data for Layer 2 permit logs (**L2 Permit**) Layer 3 permit logs (**L3 Permit**, Layer 2 deny logs (**L2 Drop**), or Layer 3 deny logs (**L3 Drop**). On each tab, you can view ACL logging data, if traffic is flowing. The data points differ according to the log type and ACL rule; for example, the following data points are included for **L3 Permit** and **L3 Deny** logs:
  - VRF
  - Alias
  - Source IP address
  - Destination IP address
  - Protocol
  - Source port
  - Destination port
  - Source MAC address
  - Destination MAC address

- Node
- Source interface
- VRF Encap
- Source EPG
- Destination EPG
- Source PC Tag
- Destination PC Tag

**Note** You can also use the **Packets** tab (next to the **Flows** tab) to access ACL logs for groups of packets (up to 10) with the same signature, source and destination. You can see what type of packets are being sent and which are being dropped.

---

## Viewing ACL Permit and Deny Logs Using the REST API

The following example shows how to view Layer 2 deny log data for traffic flows, using the REST API. You can send queries using the following MOs:

- aclogDropL2Flow
- aclogPermitL2Flow
- aclogDropL3Flow
- aclogPermitL3Flow
- aclogDropL2Pkt
- aclogPermitL2Pkt
- aclogDropL3Pkt
- aclogPermitL3Pkt

### Before you begin

You must enable permit or deny logging, before you can view ACL contract permit and deny log data.

### Procedure

---

To view Layer 3 drop log data, send the following query using the REST API:

```
GET https://apic-ip-address/api/class/aclogDropL3Flow
```

### Example:

The following example shows sample output:

```
<?xml version="1.0" encoding="UTF-8"?>
<imdata totalCount="2">
  <aclogPermitL3Flow childAction=""
```

```

dn="topology/pod-1/node-101/ndbgs/aclog/tn-common/ctx-inb
/permitl3flow-spctag-333-dpctag-444-sepgname-unknown-depgname-unknown-sip-[100:c000:a00:700:b00:0:f00:0]
-dip-[19.0.2.10]-proto-udp-sport-17459-dport-8721-smac-00:00:15:00:00:28-dmac-00:00:12:00:00:25-sintf-
[port-channel5]-vrfencap-VXLAN: 2097153" dstEpgName="unknown" dstIp="19.0.2.10"
dstMacAddr="00:00:12:00:00:25"
dstPcTag="444" dstPort="8721" lcOwn="local" modTs="never" monPolDn="" protocol="udp"
srcEpgName="unknown"
srcIntf="port-channel5" srcIp="100:c000:a00:700:b00:0:f00:0"
srcMacAddr="00:00:15:00:00:28" srcPcTag="333"
srcPort="17459" status="" vrfEncap="VXLAN: 2097153"/>
<aclogPermitL3Flow childAction=""
dn="topology/pod-1/node-102/ndbgs/aclog/tn-common/ctx-inb
/permitl3flow-spctag-333-dpctag-444-sepgname-unknown-depgname-unknown-sip-[100:c000:a00:700:b00:0:f00:0]-dip-
[19.0.2.10]-proto-udp-sport-17459-dport-8721-smac-00:00:15:00:00:28-dmac-00:00:12:00:00:25-sintf-
[port-channel5]-vrfencap-VXLAN: 2097153" dstEpgName="unknown" dstIp="19.0.2.10"
dstMacAddr="00:00:12:00:00:25"
dstPcTag="444" dstPort="8721" lcOwn="local" modTs="never" monPolDn="" protocol="udp"
srcEpgName="unknown"
srcIntf="port-channel5" srcIp="100:c000:a00:700:b00:0:f00:0"
srcMacAddr="00:00:15:00:00:28" srcPcTag="333"
srcPort="17459" status="" vrfEncap="VXLAN: 2097153"/>
</imdata>

```

## Viewing ACL Permit and Deny Logs Using the NX-OS CLI

The following steps show how to view ACL log details using the NX-OS-style CLI **show aclog** command.

The syntax for the Layer 3 command is **show aclog {permit | deny} l3 {pkt | flow} tenant <tenant\_name> vrf <vrf\_name> srcip <source\_ip> dstip <destination\_ip> srcport <source\_port> dstport <destination\_port> protocol <protocol> srcintf <source\_interface> start-time <startTime> end-time <endTime> detail**

The syntax for the Layer 2 command is **show aclog {permit | deny} l2 {flow | pkt} tenant <tenant\_name> vrf <VRF\_name> srcintf <source\_interface> vlan <VLAN\_number> detail**



**Note** The full syntax of the **show aclog** command is only available on Generation 2 Cisco Nexus 9000 series switches (with names that end in EX or FX or later, such as N9K-C93180LC-EX) and Cisco APIC Release 3.2 or later. With Generation 1 switches (with names that do not end in EX or FX) or Cisco APIC releases before 3.2, the available syntax is as above.

In Cisco APIC 3.2 and later, additional keywords are added to both versions of the command, with the **detail** keyword: **[dstEpgName <destination\_EPG\_name>| dstmac <destination\_MAC\_address> | dstpctag <destination\_PCTag> | srcEpgName <source\_EPG\_name> | srcmac <source\_MAC\_address> | srcpctag <source\_PCTag>]**





This example shows the output on Generation 1 switches, or with Cisco APIC releases before 3.2.

- Step 4** The following example shows how to use the **show acllog permit l2 pkt tenant <tenant name> vrf <vrf name> srcintf <s interface>** command to view information about default VRF Layer 2 packets sent from interface port-channel15:

```
apic1# show acllog permit l2 pkt tenant common vrf default srcintf port-channel5
acllog permit L2 Packets
      Node          srcIntf      pktLen      timeStamp
-----
                port-channel5      1      2015-03-17T21:
                                   31:14.383+00:00
```

This example shows the output on Generation 1 switches, or with Cisco APIC releases before 3.2.

---





## CHAPTER 14

# Data Plane Policing

This chapter contains the following sections:

- [Overview of Data Plane Policing, on page 183](#)
- [Guidelines and Limitations, on page 184](#)
- [Configuring Data Plane Policing for Layer 2 Interface Using the GUI, on page 185](#)
- [Configuring Data Plane Policing for Layer 3 Interface Using the APIC GUI, on page 186](#)
- [Configuring Data Plane Policing Using the REST API, on page 187](#)
- [Configuring Data Plane Policing Using NX-OS Style CLI, on page 189](#)
- [Data Plane Policing at the Endpoint Group Level, on page 195](#)

## Overview of Data Plane Policing

Use data plane policing (DPP) to manage bandwidth consumption on Cisco Application Centric Infrastructure (ACI) fabric access interfaces. DPP policies can apply to egress traffic, ingress traffic, or both. DPP monitors the data rates for a particular interface. When the data rate exceeds user-configured values, marking or dropping of packets occurs immediately. Policing does not buffer the traffic; therefore, the transmission delay is not affected. When traffic exceeds the data rate, the Cisco ACI fabric can either drop the packets or mark QoS fields in them.

Before the 3.2 release, the standard behavior for the policer was to be per-EPG member in the case of DPP policy being applied to the EPG, while the same policer was allocated on the leaf switch for the Layer 2 and Layer 3 case. This distinction was done because the DPP policer for Layer 2/Layer 3 case was assumed to be per-interface already, hence it was assumed different interfaces might get different ones. While the per-EPG DPP policy was introduced, it was clear that on a given leaf switch, several members could be present and therefore the policer it made sense to be per-member in order to avoid unwanted drops.

Starting with release 3.2, a clear semantic is given to the Data Plane Policer policy itself, as well as a new flag introducing the sharing-mode setting as presented in the CLI. Essentially, there is no longer an implicit behavior, which is different if the Data Plane Policer is applied to Layer 2/Layer 3 or to per-EPG case. Now the user has the control of the behavior. If the sharing-mode is set to **shared**, then all the entities on the leaf switch referring to the same Data Plane Policer, will share the same hardware policer. If the sharing-mode is set to **dedicated** then there would be a different HW policer allocated for each Layer 2 or Layer 3 or EPG member on the leaf switch. The policer is then dedicated to the entity that needs to be policed.

DPP policies can be single-rate, dual-rate, and color-aware. Single-rate policies monitor the committed information rate (CIR) of traffic. Dual-rate policers monitor both CIR and peak information rate (PIR) of traffic. In addition, the system monitors associated burst sizes. Three colors, or conditions, are determined by

the policer for each packet depending on the data rate parameters supplied: conform (green), exceed (yellow), or violate (red).

Typically, DPP policies are applied to physical or virtual layer 2 connections for virtual or physical devices such as servers or hypervisors, and on layer 3 connections for routers. DPP policies applied to leaf switch access ports are configured in the fabric access (infra) portion of the Cisco ACI fabric, and must be configured by a fabric administrator. DPP policies applied to interfaces on border leaf switch access ports (l3extOut or l2extOut) are configured in the tenant (fvTenant) portion of the Cisco ACI fabric, and can be configured by a tenant administrator.

The data plane policer can also be applied on an EPG so that traffic that enters the Cisco ACI fabric from a group of endpoints are limited per member access interface of the EPG. This is useful to prevent monopolization of any single EPG where access links are shared by various EPGs.

Only one action can be configured for each condition. For example, a DPP policy can conform to the data rate of 256000 bits per second, with up to 200 millisecond bursts. The system applies the conform action to traffic that falls within this rate, and it would apply the violate action to traffic that exceeds this rate. Color-aware policies assume that traffic has been previously marked with a color. This information is then used in the actions taken by this type of policer.

For information about traffic storm control, see the *Cisco APIC Layer 2 Networking Configuration Guide*.

## Guidelines and Limitations

The following are the guidelines and limitations for configuring data plane policing:

- The data plane does not police the packets transmitted from CPU and CPU bound packets on ACI fabric access interfaces.
- The **Dedicated Policer** sharing mode is not supported for Layer 2 interfaces.

The following are guidelines and limitations for EPG policing:

- Feature support begins with switch models ending in EX/FX (example: N9K-C93180YC-EX) and subsequent models.
- Egress traffic policing is not supported on the EPG level policer.
- Policer mode packet-per-second is not supported.
- Policer type 2R3C is not supported.
- Policer is not supported when **intra-EPG isolation** is enforced in EPG.
- Statistics and considerations for **tuning** include:
  - Awareness of packets that are dropped/allowed is important to know to mitigate issues or for overuse of resources.
  - Statistics are provided in the GUI using the statistics infrastructure. Statistics are exported through the REST API as for any statistic in the Cisco ACI fabric.
  - Statistics are available on per-EPG member, and are useful if the Data Plane Policer policy is of type **dedicated**, otherwise the statistics reflect the statistics of all the ports using it on the leaf switch.

- In certain cases, such as when frames goes through FCoE supported devices, these get classified into the no drop FCoE class. In FCoE devices, this can cause drop off packets when the packet length is higher than the allowed 2184 bytes.

# Configuring Data Plane Policing for Layer 2 Interface Using the GUI

## Before you begin

The tenant, VRF, and external routed network where you configure the Data Plane Policing policy must be already created.

To apply the Layer 2 Data Plane Policing policy, the policy must be added to a policy group and the policy group must be mapped to an interface profile.

## Procedure

- 
- Step 1** On the menu bar, choose **Fabric > Access Policies**.
- Step 2** In the Navigation pane, choose **Policies > Interface > Data Plane Policing**.
- Step 3** Right-click **Data Plane Policing Policing**, and click **Create a Data Plane Policing Policy**.
- Step 4** In the **Create a Data Plane Policing Policy** dialog box, in the **Name** field, enter a name for the policy.
- Step 5** For **Administrative State**, choose **enabled**.
- Step 6** For **BGP Domain Policer Mode**, choose either **Bit Policer** or **Packet Policer**.
- Step 7** For **Type**, choose **1 Rate 2 Color** or **2 Rate 3 Color**.
- Switch models ending in EX/FX (for example: N9K-C93180YC-EX) and subsequent models do not support **2 Rate 3 Color**.
- Step 8** For **Conform Action**, choose an action.
- This choice defines an actions for traffic that conforms with certain conditions.
- **Drop**: Drops the packets if the conditions are met.
  - **Mark**: Marks the packets if the conditions are met.
  - **Transmit**: Transmits the packets if the conditions are met.
- Step 9** If for **Conform Action** you chose **Mark**, perform the following substeps:
- a) For **Conform mark CoS**, enter the class of service for packets that conformed with the conditions.
  - b) For **Conform mark dscp**, enter the differentiated services code point (DSCP) for packets that conformed with the conditions.
- Step 10** The administrator can configure the CoS and DSCP values in the **Conform** and **Violate** fields.
- Step 11** If for **Type** you chose **2 Rate 3 Color**, then for **Exceed Action**, choose an action.
- This choice defines an actions for traffic that exceeds certain conditions.
- **Drop**: Drops the packets if the conditions are met.

- **Mark:** Marks the packets if the conditions are met.
- **Transmit:** Transmits the packets if the conditions are met.

**Step 12** If for **Exceed Action** you chose **Mark**, perform the following substeps:

- For **Exceed mark CoS**, enter the class of service for packets that exceeded the conditions.
- For **Exceed mark dscp**, enter the differentiated services code point (DSCP) for packets that exceeded the conditions.

**Step 13** For **Violate Action**, choose an action.

This choice defines an actions for traffic that violates to certain conditions.

- **Drop:** Drops the packets if the conditions are met.
- **Mark:** Marks the packets if the conditions are met.
- **Transmit:** Transmits the packets if the conditions are met.

**Step 14** If for **Violate Action** you chose **Mark**, perform the following substeps:

- For **Violate mark CoS**, enter the class of service for packets that violated the conditions.
- For **Violate mark dscp**, enter the differentiated services code point (DSCP) for packets that violated the conditions.

**Step 15** For **Sharing Mode**, choose **Shared Policer**.

**Shared Policer** mode allows you to apply the same policing parameters to several interfaces simultaneously. The **Dedicated Policer** mode is not supported for Layer 2 interfaces.

**Step 16** For **Rate**, enter the rate at which to allow packets are allowed into the system and choose the unit per packet.

**Step 17** For **Burst**, enter the number of packets allowed at the line rate during a burst and choose the unit per packet.

**Step 18** If for **Type** you chose **2 Rate 3 Color**, perform the following substeps:

- For **Peak Rate**, enter the peak information rate, which is the rate above which data traffic is negatively affected, and choose the unit per packet.
- For **Excessive Burst**, enter the size that a traffic burst can reach before all traffic exceeds the peak information rate, and choose the unit per packet.

**Step 19** Click **Submit**.

---

This completes DPP configuration for Layer 2. The data plane policy can now be mapped to an interface policy group that maps to a Layer 2 interface.

## Configuring Data Plane Policing for Layer 3 Interface Using the APIC GUI

### Before you begin

The tenant, VRF, and external routed network where you configure the Data Plane Policing policy is already created.

The Data Plane Policing policy must be added to a policy group and the policy group mapped to an interface profile to apply the L3 DPP policy.

### Procedure

- Step 1** In the **Navigation** pane, click on **Tenant\_name > Networking > External Routed Network > Network\_name > Logical Node Profiles > Logical Node Profile\_name > Logical Interface Profiles**, and perform the following actions.
- Right-click on **Logical Interface Profiles**, and select **Create Interface Profile**.
  - In the **Create Interface Profile** dialog box, in the **Name** field, enter a name for the profile.
  - Next to **Ingress Data Plane Policing Policy**, select **Create Data Plane Policing Policy**.
  - In the **Name** field, enter a name for the policy.
  - In the **Administrative State** field, click **enabled**.
  - Next to **Policer Mode**, select a button for either **Bit Policer** or **Packet Policer**.
  - Next to **Type**, select a button for **1 Rate 2 Color** or **2 Rate 3 Color**.
- Switch models ending in EX/FX (for example: N9K-C93180YC-EX) and subsequent models don't support 2 Rate 3 Color).
- The administrator can configure the CoS and DSCP values in the **Conform** and **Violate** fields.
  - In the **Sharing Mode** field, select the policer mode.
- Note** Shared Policer Mode allows you to apply the same policing parameters to several interfaces simultaneously.
- Next to the **Burst**, **Excessive Burst** and **Rate** fields, select the drop down arrow to set the per packet rate for **1 Rate 2 Color** policy type.
- Note** For **2 Rate 3 Color** policy type, the **Peak Rate** field is added.
- Click **Submit**.
- Step 2** Expand the **Routed Interfaces** table, in the **Path** field navigate to the interface to apply the policy and perform the following actions:
- Next to **IPv4/IPv6 Preferred Address**, enter a subnet IP address.
  - Click **OK**.
  - Click on the **SVI** tab and expand, in the **Path** field navigate to the interface to apply the policy.
  - Next to **Encap**, enter the VLAN name.
  - Next to **IPv4/IPv6 Preferred Address**, enter a subnet IP address.
  - Click **OK**.
  - Expand the **Routed Sub-Interfaces** tab, and follow the same configuration steps as for the Routed Interfaces.
  - Click **OK**. This completes DPP configuration for L3.

## Configuring Data Plane Policing Using the REST API

To police the Layer 2 traffic coming in to the leaf switch:

```

<!-- api/node/mo/uni/.xml -->
<infraInfra>
<qosDppPol name="infradpp5" burst="2000" rate="2000" be="400" sharingMode="shared"/>
<!--
  List of nodes. Contains leaf selectors. Each leaf selector contains list of node blocks
-->
<infraNodeP name="leaf1">
<infraLeafS name="leaf1" type="range">
<infraNodeBlk name="leaf1" from_"101" to_"101"/>
</infraLeafS>
<infraRsAccPortP tDn="uni/infra/accportprof-portselector1"/>
</infraNodeP>
<!--
  PortP contains port selectors. Each port selector contains list of ports. It
  also has association to port group policies
-->
<infraAccPortP name="portselector1">
<infraHPortS name="pselc" type="range">
<infraPortBlk name="blk" fromCard="1" toCard="1" fromPort="48" toPort="49"></infraPortBlk>
<infraRsAccBaseGrp tDn="uni/infra/funcprof/accportgrp-portSet2"/>
</infraHPortS>
</infraAccPortP>
<!-- FuncP contains access bundle group policies -->
<infraFuncP>
<infraAccPortGrp name="portSet2">
<infraRsQosIngressDppIfPol tnQosDppPolName="infradpp5"/>
</infraAccPortGrp>
</infraFuncP>
</infraInfra>

```

To police the Layer 2 traffic going out of the leaf switch:

```

<!-- api/node/mo/uni/.xml -->
<infraInfra>
<qosDppPol name="infradpp2" burst="4000" rate="4000"/>
<!--
  List of nodes. Contains leaf selectors. Each leaf selector contains list of node blocks
-->
<infraNodeP name="leaf1">
<infraLeafS name="leaf1" type="range">
<infraNodeBlk name="leaf1" from_"101" to_"101"/>
</infraLeafS>
<infraRsAccPortP tDn="uni/infra/accportprof-portselector2"/>
</infraNodeP>
<!--
  PortP contains port selectors. Each port selector contains list of ports. It
  also has association to port group policies
-->
<infraAccPortP name="portselector2">
<infraHPortS name="pselc" type="range">
<infraPortBlk name="blk" fromCard="1" toCard="1" fromPort="37" toPort="38"></infraPortBlk>
<infraRsAccBaseGrp tDn="uni/infra/funcprof/accportgrp-portSet2"/>
</infraHPortS>
</infraAccPortP>
<!-- FuncP contains access bundle group policies -->
<infraFuncP>
<infraAccPortGrp name="portSet2">
<infraRsQosEgressDppIfPol tnQosDppPolName="infradpp2"/>
</infraAccPortGrp>
</infraFuncP>
</infraInfra>

```

To police the Layer 3 traffic coming in to the leaf switch:



```

<!-- api/node/mo/uni/.xml -->
<fvTenant name="dppTenant">
<qosDppPol name="gmeo" burst="2000" rate="2000"/>
<l3extOut name="Outside">
<l3extInstP name="extroute"/>
<l3extLNodeP name="borderLeaf">
<l3extRsNodeL3OutAtt tDn="topology/pod-1/node-101" rtrId="10.0.0.1">
<ipRouteP ip="0.0.0.0">
<ipNextHopP nhAddr="192.168.62.2"/>
</ipRouteP>
</l3extRsNodeL3OutAtt>
<l3extLIfP name="portProfile">
<l3extRsPathL3OutAtt addr="192.168.40.1/30" ifInstT="l3-port"
tDn="topology/pod-1/paths-101/pathep-[eth1/40]"/>
<l3extRsPathL3OutAtt addr="192.168.41.1/30" ifInstT="l3-port"
tDn="topology/pod-1/paths-101/pathep-[eth1/41]"/>
<l3extRsIngressQosDppPol tnQosDppPolName="gmeo"/>
</l3extLIfP>
</l3extLNodeP>
</l3extOut>
</fvTenant>

```

To police the Layer 3 traffic going out of the leaf switch:

```

<!-- api/node/mo/uni/.xml -->
<fvTenant name="dppTenant">
<qosDppPol name="gmeo" burst="2000" rate="2000"/>
<l3extOut name="Outside">
<l3extInstP name="extroute"/>
<l3extLNodeP name="borderLeaf">
<l3extRsNodeL3OutAtt tDn="topology/pod-1/node-101" rtrId="10.0.0.1">
<ipRouteP ip="0.0.0.0">
<ipNextHopP nhAddr="192.168.62.2"/>
</ipRouteP>
</l3extRsNodeL3OutAtt>
<l3extLIfP name="portProfile">
<l3extRsPathL3OutAtt addr="192.168.40.1/30" ifInstT="l3-port"
tDn="topology/pod-1/paths-101/pathep-[eth1/40]"/>
<l3extRsPathL3OutAtt addr="192.168.41.1/30" ifInstT="l3-port"
tDn="topology/pod-1/paths-101/pathep-[eth1/41]"/>
<l3extRsEgressQosDppPol tnQosDppPolName="gmeo"/>
</l3extLIfP>
</l3extLNodeP>
</l3extOut>
</fvTenant>

```

## Configuring Data Plane Policing Using NX-OS Style CLI

### Procedure

**Step 1** Configure a Layer 2 port to carry one EPG.

#### Example:

```

apic1# conf t
apic1(config)# vlan-domain test
apic1(config-vlan)# vlan 1000-2000
apic1(config-vlan)# exit
apic1(config)# leaf 101
apic1(config-leaf)# interface ethernet 1/10

```

```

apicl(config-leaf-if)# vlan-domain member test
apicl(config-leaf-if)# exit
apicl(config-leaf)# exit
apicl(config)# tenant test1
apicl(config-tenant)# vrf context v1
apicl(config-tenant-vrf)# exit
apicl(config-tenant)# bridge-domain bd1
apicl(config-tenant-bd)# vrf member v1
apicl(config-tenant-bd)# exit
apicl(config-tenant)# application apl
apicl(config-tenant-app)# epg e1
apicl(config-tenant-app-epg)# bridge-domain member bd1
apicl(config-tenant-app-epg)# exit
apicl(config-tenant-app)# exit
apicl(config-tenant)# exit
apicl(config)# leaf 101
apicl(config-leaf)# interface ethernet 1/10
apicl(config-leaf-if)# switchport trunk allowed vlan 1001 tenant test1 application apl epg
e1
apicl(config-leaf-if)# switchport trunk allowed vlan 1501 tenant test1 application apl epg
e1
# Now the port leaf 101 ethernet 1/10 carries two vlan mapped both to the same
Tenant/Application/EPG
apicl(config-leaf-if)# exit
apicl(config-leaf)# exit

```

- a) Create a policy-map to apply to the interface.

**Example:**

```

apicl(config)# policy-map type data-plane qosTest
apicl(config-pmap-dpp)# set burst 2400 mega
apicl(config-pmap-dpp)# set cir 70 mega

apicl(config-pmap-dpp)# set sharing-mode shared
apicl(config-pmap-dpp)# exit
apicl(config)# leaf 101
apicl(config-leaf)# interface ethernet 1/10
apicl(config-leaf-if)# service-policy type data-plane input qosTest
apicl(config-leaf-if)# exit
apicl(config-leaf)# exit
apicl(config)# policy-map type data-plane qosTest2
apicl(config-pmap-dpp)# set cir 78 mega
apicl(config-pmap-dpp)# exit
apicl(config)# leaf 101
apicl(config-leaf)# interface ethernet 1/10
apicl(config-leaf-if)# service-policy type data-plane output qosTest2
apicl(config-leaf-if)# end

```

- b) Visualize the policy configured.

**Example:**

```

apicl# show policy-map type data-plane infra
Type data-plane policy-maps
=====
Global Policy
policy-map type data-plane default
  set burst unspecified
  set conform-cos-transmit unspecified
  set conform-dscp-transmit unspecified
  set conform transmit
  set excessive-burst unspecified
  set exceed-cos-transmit unspecified

```

```

    set exceed-dscp-transmit unspecified
    set exceed drop
    set mode byte
    set pir 0
    set cir 78 mega
    set type 1R2C
    set violate-cos-transmit unspecified
    set violate-dscp-transmit unspecified
    set violate drop
Global Policy
policy-map type data-plane qosTest
    set burst 2400 mega
    set cir 78 mega
    set conform-cos-transmit unspecified
    set conform-dscp-transmit unspecified
    set conform transmit
    set excessive-burst unspecified
    set exceed-cos-transmit unspecified
    set exceed-dscp-transmit unspecified
    set exceed drop
    set mode byte
    set pir 0
    set type 1R2C
    set violate-cos-transmit unspecified
    set violate-dscp-transmit unspecified
    set violate drop
Global Policy
policy-map type data-plane qosTest2
    set burst unspecified
    set conform-cos-transmit unspecified
    set conform-dscp-transmit unspecified
    set conform transmit
    set excessive-burst unspecified
    set exceed-cos-transmit unspecified
    set exceed-dscp-transmit unspecified
    set exceed drop
    set mode byte
    set pir 0
    set cir 78 mega
    set type 1R2C
    set violate-cos-transmit unspecified
    set violate-dscp-transmit unspecified
    set violate drop

```

c) Show running-config.

**Example:**

```

apic1# show runn policy-map
# Command: show running-config policy-map
# Time: Fri Jan 29 19:26:18 2016
  policy-map type data-plane default
    exit
  policy-map type data-plane qosTest
    set burst 2400 mega
    set cir 78 mega
    no shutdown
    exit
  policy-map type data-plane qosTest2
    set cir 78 mega
    no shutdown
    exit
apic1# show runn leaf 101
# Command: show running-config leaf 101
# Time: Fri Jan 29 19:26:29 2016

```

```

leaf 101
  interface ethernet 1/10
    vlan-domain member test
    switchport trunk allowed vlan 1501 tenant test1 application ap1 epg e1
    service-policy type data-plane input qosTest
    service-policy type data-plane output qosTest2
  exit
exit

```

## Step 2 Preparation to configure Layer 3 ports.

### Example:

```

apicl# conf t
apicl(config)# vlan-domain l3ports
apicl(config-vlan)# vlan 3000-3001
apicl(config-vlan)# exit
apicl(config)# tenant l3test1
apicl(config-tenant)# vrf context v1
apicl(config-tenant-vrf)# exit
apicl(config-tenant)# exit
apicl(config)# leaf 102
apicl(config-leaf)# vrf context tenant l3test1 vrf v1
apicl(config-leaf-vrf)# exit
# Configure a physical Layer 3 port
apicl(config-leaf)# interface ethernet 1/20
apicl(config-leaf-if)# no switchport
apicl(config-leaf-if)# vlan-domain member l3ports
apicl(config-leaf-if)# vrf member tenant l3test1 vrf v1
apicl(config-leaf-if)# ip address 56.1.1.1/24
apicl(config-leaf-if)# ipv6 address 2000::1/64 preferred
apicl(config-leaf-if)# exit
# Configure base interface for L3 subinterfaces
apicl(config-leaf)# interface ethernet 1/21
apicl(config-leaf-if)# vlan-domain member l3ports
apicl(config-leaf-if)# no switchport
apicl(config-leaf-if)# exit
# Configure a Layer 3 subinterface
apicl(config-leaf)# interface ethernet 1/21.3001
apicl(config-leaf-if)# vrf member tenant l3test1 vrf v1
apicl(config-leaf-if)# ip address 60.1.1.1/24
apicl(config-leaf-if)# ipv6 address 2001::1/64 preferred
apicl(config-leaf-if)# exit
# Configure a Switched Vlan Interface
apicl(config-leaf)# interface vlan 3000
apicl(config-leaf-if)# vrf member tenant l3test1 vrf v1
apicl(config-leaf-if)# ip address 70.1.1.1/24
apicl(config-leaf-if)# ipv6 address 3000::1/64 preferred
apicl(config-leaf-if)# exit
apicl(config-leaf)# exit

```

- a) Configure the policer in the tenant for Layer 3 usage.

### Example:

```

apicl(config)# tenant l3test1
apicl(config-tenant)# policy-map type data-plane iPol
apicl(config-tenant-pmap-dpp)# set cir 56 mega
apicl(config-tenant-pmap-dpp)# set burst 2000 kilo
apicl(config-tenant-pmap-dpp)# exit
apicl(config-tenant)# policy-map type data-plane ePol
apicl(config-tenant-pmap-dpp)# set burst 2000 kilo
apicl(config-tenant-pmap-dpp)# set cir 56 mega

```

```
apic1(config-tenant-pmap-dpp)# exit
apic1(config-tenant)# exit
```

- b) Apply policer on a Layer 3 interface

**Example:**

```
apic1(config)# leaf 102
apic1(config-leaf)# interface ethernet 1/20
apic1(config-leaf-if)# service-policy type data-plane input iPol
apic1(config-leaf-if)# service-policy type data-plane output ePol
apic1(config-leaf-if)# exit
apic1(config-leaf)# interface ethernet 1/21.3001
apic1(config-leaf-if)# service-policy type data-plane input iPol
apic1(config-leaf-if)# service-policy type data-plane output ePol
apic1(config-leaf-if)# exit
apic1(config-leaf)# interface vlan 3000
apic1(config-leaf-if)# service-policy type data-plane input iPol
apic1(config-leaf-if)# service-policy type data-plane output ePol
apic1(config-leaf-if)# end
```

- c) Show commands for policers used on a Layer 3 interface.

**Example:**

```
apic1# show tenant l3test1 policy-map type data-plane
Type data-plane policy-maps
=====
Policy in Tenant: l3test1
policy-map type data-plane ePol
  set burst 2000 kilo
  set conform-cos-transmit unspecified
  set conform-dscp-transmit unspecified
  set conform transmit
  set excessive-burst unspecified
  set exceed-cos-transmit unspecified
  set exceed-dscp-transmit unspecified
  set exceed drop
  set mode byte
  set pir 0
  set cir 56 mega
  set type 1R2C
  set violate-cos-transmit unspecified
  set violate-dscp-transmit unspecified
  set violate drop
Policy in Tenant: l3test1
policy-map type data-plane iPol
  set burst 2000 kilo
  set burst unspecified
  set conform-cos-transmit unspecified
  set conform-dscp-transmit unspecified
  set conform transmit
  set excessive-burst unspecified
  set exceed-cos-transmit unspecified
  set exceed-dscp-transmit unspecified
  set exceed drop
  set mode byte
  set pir 0
  set cir 56 mega
  set type 1R2C
  set violate-cos-transmit unspecified
  set violate-dscp-transmit unspecified
  set violate drop
```

- d) Show running-config for policers used for Layer 3.

**Example:**

```

apic1# show runn tenant l3test1
# Command: show running-config tenant l3test1
# Time: Fri Jan 29 19:48:20 2016
tenant l3test1
  vrf context v1
  exit
  policy-map type data-plane ePol
  set burst 2000 kilo
  set cir 56 mega
  no shutdown
  exit
  policy-map type data-plane iPol
  set burst 2000 kilo
  set cir 56 mega
  no shutdown
  exit
exit
apic1# show running-config leaf 102
# Command: show running-config leaf 102
# Time: Fri Jan 29 19:48:33 2016
leaf 102
  vrf context tenant l3test1 vrf v1
  exit
  interface vlan 3000
  vrf member tenant l3test1 vrf v1
  ip address 70.1.1.1/24
  ipv6 address 3000::1/64 preferred
  bfd ip tenant mode
  bfd ipv6 tenant mode
  service-policy type data-plane input iPol
  service-policy type data-plane output ePol
  exit
  interface ethernet 1/20
  vlan-domain member l3ports
  no switchport
  vrf member tenant l3test1 vrf v1
  ip address 56.1.1.1/24
  ipv6 address 2000::1/64 preferred
  bfd ip tenant mode
  bfd ipv6 tenant mode
  service-policy type data-plane input iPol
  service-policy type data-plane output ePol
  exit
  interface ethernet 1/21
  vlan-domain member l3ports
  no switchport
  bfd ip tenant mode
  bfd ipv6 tenant mode
  exit
  interface ethernet 1/21.3001
  vrf member tenant l3test1 vrf v1
  ip address 60.1.1.1/24
  ipv6 address 2001::1/64 preferred
  bfd ip tenant mode
  bfd ipv6 tenant mode
  service-policy type data-plane input iPol
  service-policy type data-plane output ePol
  exit
  exit
apic1#

```

# Data Plane Policing at the Endpoint Group Level

Data Plane Policing (DPP) can be applied to an endpoint group (EPG). The policing of the traffic is applied to all the EPG members on every leaf switch where the EPG is deployed.

Prior to the 3.2(1) release, each EPG member had its own policer. Beginning in the 3.2(1) release, the behavior is dependent on the sharing-mode property (if configured through the CLI or GUI) on the Data Plane Policer. If that is set to **dedicated**, then the situation is similar to before the 3.2(1) release. If the sharing-mode is set to **shared**, then all the members in the same slice using the same Data Plane Policer policy use the hardware policer on the leaf switch.

For example, an EPG has the following members:

- Leaf 101, Eth1/1, vlan-300
- Leaf 101, Eth1/2, vlan-301
- Leaf 102, Eth1/2, vlan-500

In this case, each member will limit the traffic according to the policer, independent from the other members. If the Data Plane Policer has the sharing-mode set to **shared**, then all the members in the same slice above use only one policer on the leaf switch.

The Data Plane Policer works independently on Leaf 101 and Leaf 102 if the sharing-mode is set to **dedicated**. For example:

- Policer-A (100Mbps policing) is applied to EPG1 (Leaf101 e1/1 vlan-300 and e1/2 vlan-301. Leaf 102 e1/2 vlan-500)
- Leaf 101: police traffic at the EPG1 level, which is applied to traffic through E1/1 vlan-300 and E1/2 vlan-301 (100Mbps for each interface).
- Leaf 102: police traffic at the EPG1 level, which is applied to traffic through E1/2 vlan-500 (another 100Mbps for each interface).

The total is up to 300Mbps for EPG1.

If the sharing-mode is set to **shared**, 100Mbps is shared across EPGs using the same policer if the interfaces are in the same slice. For example:

- Policer-A (100Mbps policing) applied to EPG1 and EPG2.
- Leaf 101: police traffic at EPG1 and EPG2 in total.
- Leaf 102: police traffic at EPG1 and EPG2 in total.

The total is up to 200Mbps for EPG1 and EPG2 if the interfaces are in the same slice.

The following are limitations for Data Plane Policing at the EPG level:

- EPG policer feature is supported with switch models that have -EX, -FX, or later suffixes in the product ID.
- Egress traffic policing is not supported for the EPG level policer.
- Policer mode **Packet-per-second** is not supported.
- Policer type 2R3C is not supported in EPG policer.

- Policer is not supported when **intra-EPG isolation-enforced** is applied to the EPG.
- The scale limit allows for 128 EPG policers supported per node.

## Configuring Data Plane Policing at the Endpoint Group Level Using CLI

### Procedure

---

Define the policer:

#### Example:

```

apicl# conf t
apicl(config)# vlan-domain test
apicl(config-vlan)# vlan 1000-2000
apicl(config-vlan)# exit
apicl(config)# leaf 101
apicl(config-leaf)# interface ethernet 1/10
apicl(config-leaf-if)# vlan-domain member test
apicl(config-leaf-if)# exit
apicl(config-leaf)# exit
apicl(config)# tenant test1
apicl(config-tenant)# vrf context v1
apicl(config-tenant-vrf)# exit
apicl(config-tenant)# bridge-domain bd1
apicl(config-tenant-bd)# vrf member v1
apicl(config-tenant-bd)# exit
apicl(config)# policy-map type data-plane poll
apicl(config-pmap-dpp)# set burst 2400 mega
apicl(config-pmap-dpp)# set cir 78 mega
apicl(config-pmap-dpp)# exit
apicl(config-tenant)# application ap1
apicl(config-tenant-app)# epg e1
apicl(config-tenant-app-epg)# bridge-domain member db1
apicl(config-tenant-app-epg)# service-policy type data-plane poll
apicl(config-tenant-app-epg)# exit
apicl(config-tenant-app)# exit
apicl(config-tenant)# exit
apicl(config)# leaf 101
apicl(config-leaf)# interface ethernet 1/10
apicl(config-leaf-if)# switchport trunk allowed vlan 1001 tenant test1 application ap1 epg
e1
apicl(config-leaf-if)# exit
apicl(config-leaf)# exit

```

---



# Configuring Data Plane Policing at the Endpoint Group Level Using the APIC GUI

## Procedure

In the **Tenants** pane, click on **Tenant\_name** > **Policies** > **Protocol** > **Data Plane Policing**. Right-click on **Data Plane Policing** to **Create Data Plane Policing Policy**.

- a) In the **Name** field, enter a name for the policy.
- b) In the **Administrative State** field, click **enabled**.
- c) Next to **Policer Mode**, select a button for either **Bit Policer** or **Packet Policer**.
- d) Next to **Type**, select a button for **1 Rate 2 Color**.
- e) For **Conform Action**, select **Drop**, **Mark**, or **Transmit**.
- f) The administrator can configure the CoS and DSCP values in the **Conform** and **Violate** fields.
- g) Next to the **Burst**, **Excessive Burst** and **Rate** fields, click the drop down arrow to select from the following:
  - **Bytes/Packets**
  - **Kilo Bytes/Packets**
  - **Mega Bytes/Packets**
  - **Giga Bytes/Packets**
  - **Milli Seconds**
  - **Micro Seconds**

## Configuring Data Plane Policing at the Endpoint Group Level Using Rest API

To police the traffic coming into the leaf switch:

```
<!-- api/node/mo/.xml -->
<polUni>
  <fvTenant name="t1">
    <qosDppPol name="gmeo" burst="2000" rate="2000"/>
    <fvAp name="ap1">
      <fvAEPg name="ep1">
        <fvRsDppPol tnQosDppPolName="gmeo"/>
      </fvAEPg>
    </fvAp>
  </fvTenant>
</polUni>
```

## Accessing Statistics for the Data Plane Policer at the Endpoint Group Level in the GUI

DPP at the EPG level is used to police traffic at the EPG member level. As such, statistics are integral in ensuring the policer is dropping substantial traffic. Statistics are reported at the EPG member level for fine granularity.

### Procedure

---

- Step 1** In the **Tenants** pane, click on **Tenant\_name** > **Application EPGs** > **EPG Members** > **Static EPG Members** .
- Step 2** Select a node.
- Step 3** Click **Select Stats**.
- Select a **Sampling Interval** unit of time.
  - From the **Available** policer attributes, use the arrows to choose the attributes. You can select up to two attributes.
  - Click **Submit**.
- 

### What to do next

You will see a graphical representation of the DPP statistics.



## CHAPTER 15

# HTTPS Access

---

This chapter contains the following sections:

- [Overview, on page 199](#)
- [Configuring Custom Certificate Guidelines, on page 199](#)
- [Modifying the SSL Cipher Configuration, on page 200](#)
- [Configuring a Custom Certificate for Cisco ACI HTTPS Access Using the GUI, on page 201](#)
- [Configuring the Default SSL Protocols and Diffie-Hellman Key Exchange Using the GUI, on page 204](#)
- [Enabling Certificate Based Authentication Using the NX-OS CLI, on page 204](#)
- [About SSL Ciphers, on page 205](#)

## Overview

This article provides an example of how to configure a custom certificate for HTTPS access when using Cisco ACI.

## Configuring Custom Certificate Guidelines

- Exporting a private key that is used to generate a Certificate Signing Request (CSR) on the Cisco Application Policy Infrastructure Controller (APIC) is not supported. If you want to use the same certificate on multiple servers through a wildcard in the Subject Alternative Name (SAN) field, such as "\*cisco.com," by sharing the private key that was used to generate the CSR for the certificate, generate the private key outside of Cisco Application Centric Infrastructure (ACI) fabric and import it to the Cisco ACI fabric.
- You must download and install the public intermediate and root CA certificates before generating a Certificate Signing Request (CSR). Although a root CA Certificate is not technically required to generate a CSR, Cisco requires the root CA certificate before generating the CSR to prevent mismatches between the intended CA authority and the actual one used to sign the CSR. The Cisco APIC verifies that the certificate submitted is signed by the configured CA.
- To use the same public and private keys for a renewed certificate generation, you must satisfy the following guidelines:
  - You must preserve the originating CSR as it contains the public key that pairs with the private key in the key ring.

- The same CSR used for the originating certificate must be resubmitted for the renewed certificate if you want to re-use the public and private keys on the Cisco APIC.
- Do not delete the original key ring when using the same public and private keys for the renewed certificate. Deleting the key ring will automatically delete the associated private key used with CSRs.
- Cisco ACI Multi-Site, VCPlugin, VRA, and SCVMM are not supported for certificate-based authentication.
- Only one SSL certificate is allowed per Cisco APIC cluster.
- You must disable certificate-based authentication before downgrading to release 4.0(1) from any later release.
- To terminate the certificate-based authentication session, you must log out and then remove the CAC card.
- The custom certificate configured for the Cisco APIC will be deployed to the leaf and spine switches. If the URL or DN that is used to connect to the fabric node is within the **Subject** or **Subject Alternative Name** field, the fabric node will be covered under the certificate.
- The Cisco APIC GUI can accept a certificate with a maximum size of 4k bytes.

## Modifying the SSL Cipher Configuration

SSL ciphers can be enabled, disabled, or removed entirely. Depending on the desired cipher settings, you should understand which exact combination is required. Disabling and enabling ciphers in a manner that results in no ciphers remaining is a misconfiguration and will result in NGINX failing validation.

NGINX uses the OpenSSL cipher list format. For information about the format, go to the OpenSSL website.

## Mapping the Cisco APIC SSL Configuration Options to the Cipher List Formatting

Enabling a cipher results in the cipher being written to the NGINX configuration file. Disabling a cipher results in the cipher being written in the NGINX configuration file with a preceding exclamation mark (!). For example, disabling "EEDCH" will cause it to be written as "!EEDCH". Removing a cipher will result in the cipher not being written the NGINX configuration file at all.



**Note** As stated in the OpenSSL cipher list format document, "If ! is used then the ciphers are permanently deleted from the list. The ciphers deleted can never reappear in the list even if they are explicitly stated." This can result in the removal of combination ciphers referencing the one that was set to "Disabled," regardless of the ciphers' "Enabled" state.

Example: Disabling "EEDCH," but enabling "EECDH+aRSA+SHA384." This will cause the following to be written to the NGINX configuration file: "!EEDCH:EECDH+aRSA+SHA384". The "!EEDCH" will prevent "EECDH+aRSA+SHA384" from ever being added. This will result in no ciphers being used, which will fail NGINX validation and prevent NGINX updates from succeeding, such as applying custom HTTPS certificates.

## Testing the Cipher List Format Before Modifying the Cisco APIC SSL Configuration

Before making any cipher modifications to the Cisco Application Policy Infrastructure Controller (APIC), validate the results of the planned cipher combination using the `openssl ciphers -V 'cipher_list'` command and ensure that the cipher output matches your desired result.

Example:

```
apic# openssl ciphers -V 'EECDH+aRSA+SHA256:EECDH+aRSA+SHA384'
      0xC0,0x27 - ECDHE-RSA-AES128-SHA256 TLSv1.2 Kx=ECDH      Au=RSA  Enc=AES (128)
Mac=SHA256
      0xC0,0x28 - ECDHE-RSA-AES256-SHA384 TLSv1.2 Kx=ECDH      Au=RSA  Enc=AES (256)
Mac=SHA384
```

If your tested cipher list results in an error or "no cipher match," do not apply this configuration to the Cisco APIC. Doing so can result in NGINX issues with symptoms including making the Cisco APIC GUI inaccessible and breaking custom certificate application.

Example:

```
apic# openssl ciphers -V '!EECDH:EECDH+aRSA+SHA256:EECDH+aRSA+SHA384'
Error in cipher list
132809172158128:error:1410D0B9:SSL routines:SSL_CTX_set_cipher_list:no cipher
match:ssl_lib.c:1383:
```

## Configuring a Custom Certificate for Cisco ACI HTTPS Access Using the GUI

**CAUTION: PERFORM THIS TASK ONLY DURING A MAINTENANCE WINDOW AS THERE IS A POTENTIAL FOR DOWNTIME.** The downtime affects access to the Cisco Application Policy Infrastructure Controller (APIC) cluster and switches from external users or systems and not the Cisco APIC to switch connectivity. The NGINX process on the switches will also be impacted, but that will be only for external connectivity and not for the fabric data plane. Access to the Cisco APIC, configuration, management, troubleshooting, and such will be impacted. The NGINX web server running on the Cisco APIC and switches will be restarted during this operation.

### Before you begin

Determine from which authority you will obtain the trusted certification so that you can create the appropriate Certificate Authority.

### Procedure

- 
- Step 1** On the menu bar, choose **Admin > AAA**.
  - Step 2** In the **Navigation** pane, choose **Security**.
  - Step 3** In the **Work** pane, choose **Public Key Management > Certificate Authorities > Create Certificate Authority**.
  - Step 4** In the **Create Certificate Authority** dialog box, in the **Name** field, enter a name for the certificate authority.

**Step 5** In the **Certificate Chain** field, copy the intermediate and root certificates for the certificate authority that will sign the Certificate Signing Request (CSR) for the Cisco APIC.

The certificate should be in Base64 encoded X.509 (CER) format. The intermediate certificate is placed before the root CA certificate. It should look similar to the following example:

```
-----BEGIN CERTIFICATE-----
<Intermediate Certificate>
-----END CERTIFICATE-----
-----BEGIN CERTIFICATE-----
<Root CA Certificate>
-----END CERTIFICATE-----
```

**Step 6** Click **Submit**.

**Step 7** In the **Navigation** pane, choose **Public Key Management > Key Rings**.

**Step 8** In the **Work** pane, choose **Actions > Create Key Ring**.

The key ring enables you to manage a private key (imported from external device or internally generated on APIC), a CSR generated by the private key, and the certificate signed via the CSR.

**Step 9** In the **Create Key Ring** dialog box, in the **Name** field, enter a name.

**Step 10** In the **Certificate** field, do not add any content if you will generate a CSR using the Cisco APIC through the key ring. Alternately, add the signed certificate content if you already have one that was signed by the CA from the previous steps by generating a private key and CSR outside of the Cisco APIC,

**Step 11** In the **Modulus** field, click the radio button for the desired key strength.

**Step 12** In the **Certificate Authority** field, from the drop-down list, choose the certificate authority that you created earlier, then click **Submit**.

**Step 13** In the **Private Key** field, do not add any content if you will generate a CSR using the Cisco APIC through the key ring. Alternately, add the private key used to generate the CSR for the signed certificate that you entered in step 10.

**Note** Do not delete the key ring. Deleting the key ring will automatically delete the associated private key used with CSRs.

If you have not entered the signed certificate and the private key, in the **Work** pane, in the **Key Rings** area, the **Admin State** for the key ring created displays **Started**, waiting for you to generate a CSR. Proceed to step 14.

If you entered both the signed certificate and the private key, in the **Key Rings** area, the **Admin State** for the key ring created displays **Completed**. Proceed to step 23.

**Step 14** In the **Navigation** pane, choose **Public Key Management > Key Rings > key\_ring\_name**.

**Step 15** In the **Work** pane, choose **Actions > Create Certificate Request**.

**Step 16** In the **Subject** field, enter the common name (CN) of the CSR.

You can enter the fully qualified domain name (FQDN) of the Cisco APICs using a wildcard, but in a modern certificate, we generally recommend that you enter an identifiable name of the certificate and enter the FQDN of all Cisco APICs in the **Alternate Subject Name** field (also known as the SAN – Subject Alternative Name) because many modern browsers expect the FQDN in the SAN field.

**Step 17** In the **Alternate Subject Name** field, enter the FQDN of all Cisco APICs, such as "DNS:apic1.example.com,DNS:apic2.example.com,DNS:apic3.example.com" or "DNS:\*example.com".

Alternatively, if you want SAN to match an IP address, enter the Cisco APICs' IP addresses with the following format:

IP:192.168.2.1

You can use DNS names, IPv4 addresses, or a mixture of both in this field. IPv6 addresses are not supported.

**Step 18** Fill in the remaining fields as appropriate.

**Note** Check the online help information available in the **Create Certificate Request** dialog box for a description of the available parameters.

**Step 19** Click **Submit**.

Inside the same key ring, the **Associated Certificate Request** area is now displayed with the **Subject**, **Alternate Subject Name** and other fields you entered in the previous steps along with the new field **Request**, which contains the content of the CSR that is tied to this key ring. Copy the content from the **Request** field to submit the content to the same certificate authority that is tied to this key ring for signing.

**Step 20** In the **Navigation** pane, choose **Public Key Management > Key Rings > key\_ring\_name**.

**Step 21** In the **Work** pane, in the **Certificate** field, paste the signed certificate that you received from the certificate authority.

**Step 22** Click **Submit**.

**Note** If the CSR was not signed by the Certificate Authority indicated in the key ring, or if the certificate has MS-DOS line endings, an error message is displayed and the certificate is not accepted. Remove the MS-DOS line endings.

The key is verified, and in the **Work** pane, the **Admin State** changes to **Completed** and is now ready for use in the HTTP policy.

**Step 23** On the menu bar, choose **Fabric > Fabric Policies**.

**Step 24** In the **Navigation** pane, choose **Pod Policies > Policies > Management Access > default**.

**Step 25** In the **Work** pane, in the **Admin Key Ring** drop-down list, choose the desired key ring.

**Step 26** (Optional) For Certificate based authentication, in the **Client Certificate TP** drop-down list, choose the previously created Local User policy and click **Enabled** for **Client Certificate Authentication state**.

**Step 27** Click **Submit**.

All web servers restart. The certificate is activated, and the non-default key ring is associated with HTTPS access.

---

### What to do next

You must remain aware of the expiration date of the certificate and take action before it expires. To preserve the same key pair for the renewed certificate, you must preserve the CSR as it contains the public key that pairs with the private key in the key ring. Before the certificate expires, the same CSR must be resubmitted. Do not delete or create a new key ring as deleting the key ring will delete the private key stored internally on the Cisco APIC.

# Configuring the Default SSL Protocols and Diffie-Hellman Key Exchange Using the GUI

This procedure configures the default SSL protocols and Diffie-Hellman key exchange. You must configure these parameters based on the security policy of your organization and the needs of any applications that you use.

## Procedure

---

**Step 1** On the menu bar, choose **Fabric > Fabric Policies**.

**Step 2** In the **Navigation** pane, choose **Policies > Pod > Management Access > default**.

**Step 3** In the **Work** pane, find the **HTTPS** section.

- a) For **SSL Protocols**, put a check in the boxes for the transport layer security (TLS) versions that your network allows. Leave the box empty for any TLS version that your network does not allow.
- b) For **DH Param**, choose the desired key size (in bits).

Choosing one of the key sizes enables the standard Diffie-Hellman (DH) key exchange in addition to the elliptic-curve Diffie-Hellman (ECDH) key exchange and uses the chosen number of bits for the DH key exchange. Choosing **None** instead uses only the elliptic-curve ECDH key exchange. In any case, ECDH always uses 256 bits.

- c) Click **Submit**.
- 

# Enabling Certificate Based Authentication Using the NX-OS CLI

## Procedure

---

To enable Certificate Based authentication:

### Example:

To enable CAC for https access:

```
configure terminal
comm-policy default
https
  client-cert-ca <ca name>
  client-cert-state-enable
```

To disable:

```
configure terminal
comm-policy default
https
  no client-cert-state-enable
  no client-cert-ca
```

---



# About SSL Ciphers

The Cisco Application Centric Infrastructure (ACI) Representational State Transfer (REST) Application Programming Interface (API) has gone through an evolution from the day the solution debuted to recent versions where the HTTPS/SSL/TLS support has gotten increasingly more stringent. This document is intended to cover the evolution of HTTPS, SSL, and TLS support on the Cisco ACI REST API and provide customers with a guide of what is required for a client to utilize the REST API securely.

HTTPS is a protocol that utilizes either Secure Socket Layers (SSL) or Transport Layer Security (TLS) to form a secure connection for a HTTP session. SSL or TLS is used to encrypt the traffic between a client and a HTTP server. In addition, servers that support HTTPS have a certificate that can usually be used by the client to verify the server's authenticity. This is the opposite of the client authenticating with the server. In this case, the server is saying, "I am server\_xyz and here is the certificate that proves it." The client can then utilize that certificate to verify the server is "server\_xyz."

There are other important aspects to SSL/TLS that involve the supported encryption ciphers available in each protocol as well as the inherent security of the SSL or TLS protocols. SSL has gone through three iterations - SSLv1, SSLv2 and SSLv3 - all of which are now considered insecure. TLS has gone through three iterations - TLSv1, TLSv1.1 and TLSv1.2 - of which only TLSv1.1 and TLSv1.2 are considered "secure." Ideally, a client should utilize the highest available TLS version it can and the server should support only TLSv1.1 and TLSv1.2. However, most servers must keep TLSv1 for outdated clients.

Almost all modern browsers support both TLSv1.1 and TLSv1.2. However, a client that utilizes HTTPS may not be a browser. The client may be a java application or a python script that communicates with a web server and must negotiate HTTPS/TLS. In this type of a situation, the questions of what is supported and where becomes much more important.

## Determining the Supported SSL Ciphers Using the CLI

### Before you begin

This section describes how to use the CLI to determine which SSL ciphers are supported.

### Procedure

**Step 1** Get the supported ciphers in your openssl environment, shown as follows:

**Example:**

```
openssl ciphers 'ALL:eNULL'
```

**Step 2** Separate the ciphers using sed or some other tool, shown as follows:

**Example:**

```
openssl ciphers 'ALL:eNULL' | sed -e 's:/\n/g'
```

**Step 3** Loop over the ciphers and poll the APIC to see which ones are supported, shown as follows:

**Example:**

```
openssl s_client -cipher ?<some cipher to test?> -connect <apic ipaddress>:<ssl port, usually 443>
```

See the following example cipher:

**Example:**

```
openssl s_client -cipher ?ECDHE-ECDSA-AES128-GCM-SHA256? -connect 10.1.1.14:443
```

**Note** If the response contains `CONNECTED`, then the cipher is supported.

---



## CHAPTER 16

# Additional ACI Security Features

---

This chapter contains the following sections:

- [Additional Security Features](#), on page 207
- [Restricting Infra VLAN Traffic](#), on page 207
- [Turning Off Generated Session Log Files in APIC](#), on page 208

## Additional Security Features

The following are a list of security features currently supported in ACI but documented in other configuration guides found at <https://www.cisco.com/c/en/us/support/cloud-systems-management/application-policy-infrastructure-controller-apic/tsd-products-support-series-home.html>:

- For **Contract** configuration see the *Cisco APIC Basic Configuration Guide, Release 3.x* and the *Operating Cisco Application Centric Infrastructure*.
- For **EPG Communication Rules** see the *Use vzAny to Automatically Apply Communication Rules to all EPGs in a VRF* Knowledge-Based article.
- For **In-Band and Out-of-Band Management Access** see the *Cisco APIC and Static Management Access* Knowledge-Based article, and the *Cisco APIC Layer 4 to Layer 7 Services Deployment Guide, Release 2.2(3)*.
- For **Intra-EPG Isolation Enforcement** see the *Cisco ACI Virtualization Guide, Release 3.0(1)*.
- For **Traffic Storm Control** see the *Cisco APIC Layer 2 Networking Configuration Guide*.

## Restricting Infra VLAN Traffic

For stronger isolation between hypervisors in the fabric, you can restrict Infra VLAN traffic to only network paths specified by Infra security entry policies. When you enable this feature, each leaf switch limits Infra VLAN traffic from compute nodes to allow only VXLAN traffic. The switch also limits traffic to leaf nodes to allow only OpFlex, DHCP/ARP/ICMP, and iVXLAN/VXLAN traffic. APIC management traffic is allowed on front panel ports on the Infra VLAN.

This feature is disabled by default. To enable the feature, perform the following steps:

### Procedure

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- Step 1** On the menu bar, choose **System > System Settings**.
  - Step 2** In the Navigation pane, click **Fabric-Wide Settings**.
  - Step 3** In the Work pane, check the checkbox for **Restrict Infra VLAN Traffic**.
  - Step 4** Click **Submit**.
- 

## Turning Off Generated Session Log Files in APIC

This section describes how to turn off the generated logs in APIC. If you have configured any sort of monitoring for your fabric, you will see the following log file:

```
Body of session record log example:  
From-127.0.0.1-client-type-REST-Success
```

To turn off the generated session log files in APIC, perform the following steps:

### Procedure

---

- Step 1** On the menu bar, choose **ADMIN > AAA**.
  - Step 2** In the AAA pane, click **Security**.
  - Step 3** In the **User Management – Security** pane, verify that the default **Management Settings** pane is chosen.
  - Step 4** In the **Include Refresh in Session Records** field, uncheck the box to disable the generated session log files.
  - Step 5** Click **Submit**.
  - Step 6** Click **Submit Changes**.
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