User Access, Authentication, and Accounting

This chapter contains the following sections:

- Access Rights Workflow Dependencies, on page 1
- User Access, Authorization, and Accounting, on page 1
- Configuring a Local User, on page 3
- Configuring a Remote User, on page 6
- Configuring Windows Server 2008 LDAP for APIC Access with Cisco AVPair, on page 12
- Configuring APIC for LDAP Access, on page 14
- Changing the Default Behavior for Remote Users with Missing or Bad Cisco AV Pairs, on page 16
- Changing Default Behavior for Remote Users with Missing or Bad Cisco AV Pairs Using the NX-OS Style CLI, on page 16
- About Signature-Based Transactions, on page 17
- Accounting, on page 25
- Routed Connectivity to External Networks as a Shared Service Billing and Statistics, on page 26

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.

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.
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 set of roles
- 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

The ACI fabric manages access privileges at the managed object (MO) level. A privilege is an MO that enables or restricts access to a particular function within the system. For example, fabric-equipment is a privilege bit. This bit is set by the Application Policy Infrastructure Controller (APIC) on all objects that correspond to equipment in the physical fabric.

A role is a collection of privilege bits. For example, because an “admin” role is configured with privilege bits for “fabric-equipment” and “tenant-security,” the “admin” role has access to all objects that correspond to equipment of the fabric and tenant security.

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.

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
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.

**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+ and TACACS+ provider group.
  - 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 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 User Identity dialog box, enter a Login ID and Password for the user, and click Next.
Step 6  In the Security dialog box, choose the desired security domain for the user, and click Next.
Step 7  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 8  In the User Identity dialog box, perform the following actions:
   a) In the Login ID field, add an ID.
   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 client-based authentication, in the User Certificate Attribute field, enter the user identity from the authentication certificate.
   e) Click Finish.

Step 9  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.
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**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>On the menu bar, choose <strong>ADMIN</strong> &gt; <strong>Security Management</strong> &gt; <strong>Local Users</strong>.</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>In the <strong>Navigation</strong> pane, click the name of the user that you previously created.</td>
</tr>
</tbody>
</table>
| **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**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
</table>
| **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.
extit           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/policymgr/mo/uni/userext.xml
POST CONTENT:

```xml
<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>
```

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
```

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.

The APIC supports the following regexes:

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

**Examples:**

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

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

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

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

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

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

Best Practice for Assigning AV Pairs

As best practice, Cisco recommends 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 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 APIC and login as an administrator (using a remote user account). Once logged in, run the following commands (replace “userid” with the username you logged in with):

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

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.

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:

```plaintext
* 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:

```plaintext
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:
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.

a) On the menu bar, choose Admin > AAA.
b) In the Navigation pane, choose TACACS+ Management > TACACS+ Providers.
c) In the Work pane, choose Actions > Create TACACS+ Provider.
d) 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 TACACS+ Provider Group.

a) In the Navigation pane, choose TACACS+ Management > TACACS+ Provider Groups.
b) In the Work pane, choose Actions > Create TACACS+ Provider Group.
c) Specify the TACACS+ provider group name, description, and providers as appropriate.

Step 3

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 API 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, choose **RADIUS Management > RADIUS Providers**.

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 RADIUS provider group.

a) In the **Navigation pane**, choose **RADIUS Management > RADIUS Provider Groups**.

b) In the **Work pane**, choose **Actions > Create RADIUS Provider Group**.
c) Specify the RADIUS Provider Group name, description, and providers as appropriate.

Step 3
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 Cisco APICs are installed and online; the Cisco 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 Cisco APIC as a client.

a) Navigate to Network Resources > Network Devices Groups > Network Devices and AAA Clients.
b) Specify the client name, the Cisco 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.

c) 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 Cisco APIC Provider key(s).

Step 2
Create the Identity Group.

a) Navigate to Users and Identity Stores > Internal Groups option.
b) Specify the Name, and Parent Group as appropriate.
Step 3  Map users to the Identity Group.
   a) In the Navigation pane, click the Users and Identity Stores > Internal Identity Stores > Users option.
   b) Specify the user Name, and Identity Group as appropriate.

Step 4  Create the Policy Element.
   a) Navigate to the Policy Elements option.
   b) 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.
   c) 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.

      For example, if the cisco-av-pair 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.

Step 5  Create a service selection rule.
   a) 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 Cisco APIC. Verify that the users have access to the correct Cisco 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 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.
  a) Navigate to Start > Run, type `mmc` and press Enter. The Microsoft Management Console (MMC) opens.
  b) Navigate to File > Add/Remove Snap-in > Add.
  c) In the Add Standalone Snap-in dialog box, select the Active Directory Schema and click Add. The MMC Console opens.
  d) Right-click the Attributes folder, select the Create Attribute option. The Create New Attribute dialog box opens.
  e) 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.
  f) Click OK to save the attribute.

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

  a) In the ADSI Edit dialog box, locate a user who needs access to the Cisco APIC.
  b) Right-click on the user name, and choose Properties.
The <user> Properties dialog box opens.
c) 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.

d) 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 LDAP Management > LDAP Providers.
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.
• 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
In the APIC, configure the LDAP Provider Group.

a) In the **Navigation** pane, choose **LDAP Management > LDAP Provider Groups**.
b) Right-click **LDAP Provider Groups** and click **Create LDAP Provider Group**.
c) Specify the following information as appropriate.
   - **Name**—Enter a name for the LDAP provider group
   - **Description**—(Optional) Enter a description of the LDAP provider group
   - **Auth Choice**—Choose the authorization option, which can be **CiscoAVPair** (the default) or **LdapGroupMap**.

   **Note** The **LdapGroupMap** option requires creating an LDAP group map.

   - **LDAP Group Map**—(For the **LdapGroupMap** option) Click the drop-down arrow and choose the LDAP group map.
   - **Providers**—Click the + to enter an LDAP provider name, priority, and description.

### Step 3
On the APIC, configure the login domain for LDAP.

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 LDAP configuration steps. Next, test the APIC LDAP login access.
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 **AAA Authentication**.

Step 3
In the **Work** pane, in the **Properties** 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:

```
apic1# configure
```

Step 2
Configure the aaa user default role.

Example:

```
apic1(config)# aaa user default-role
assign-default-role assign-default-role
no-login no-login
```
Step 3

Configure the aaa authentication login methods.

Example:

```
apic1(config)# aaa authentication
login Configure methods for login

apic1(config)# aaa authentication login
console Configure console methods
default Configure default methods
domain Configure domain methods

apic1(config)# aaa authentication login console
<CR>

apic1(config)# aaa authentication login domain
WORD Login domain name
fallback
```
• 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.

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:
```bash
$ 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:
```bash
$ openssl x509 -text -in userabc.crt
Certificate:  
  Data:  
    Version: 3 (0x2)  
    Serial Number:  
    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:  
          cc:e4:7f:61:14:3c:9e:ae:d8:88:be:80:a0:4a:90:  
          5f:bcc:35:2d:b1:07:b9:ec:e1  
        Exponent: 65537 (0x10001)
X509v3 extensions:  
  X509v3 Subject Key Identifier:  
  X509v3 Authority Key Identifier:  
```
Configuring a Local User

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 are 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:

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

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

c) In the **Confirm Password** field, confirm the password.

d) (Optional) For client-based authentication, in the **User Certificate Attribute** field, enter the user identity from the authentication certificate.

e) 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:**

```json
{
    "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-----
MIICjjCCAfegAwIBAgIJAMQnbE<snipped content>==
-----END CERTIFICATE-----",
                    },
                },
                "children": []
            },
        ],
        "aaaUserDomain": {
            "attributes": {
                "name": "all",
            },
            "children": [
                {
                    "aaaUserRole": {
                        "attributes": {
                            "name": "aaa",
                            "privType": "writePriv",
                        },
                        "children": []
                    },
                    "children": []
                },
                {
                    "aaaUserRole": {
                        "attributes": {
                            "name": "access-admin",
                            "privType": "writePriv",
                        },
                        "children": []
                    },
                    "children": []
                },
                {
                    "aaaUserRole": {
                        "attributes": {
                            "name": "admin",
                            "privType": "writePriv",
                        },
                        "children": []
                    },
                    "children": []
                }
            ]
        }
    }
}
```

---
Creating a Local User Using Python SDK

Procedure

Create a local user.

Example:

```python
#!/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()

for user in userRoles:
    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+OTqK0CeAZjl7+Gute2R1Ww8OGgtzE0ws1lx8fIXX14V79Zl7
0u8lJH0CB4wE2vD1CQxkv5KQazCIC0+Bn0703qF/BeIpIzYChD6gCX3f7q
1cJGX+R6HAqGeK7k97cNhX1WEooobFPe/oaJtpj0u3td0jhf/9uJ6G6Jv6Ro=

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 in the API as a cookie in the header of the request.

Example:

    APIC-Request-Signature=P+OTqK0CeAZjl7+Gute2R1Ww8OGgtzE0ws1lx8f
IXX14V79Zl7Ou8lJH0CB4wE2vD1CQxkv5KQazCIC0+Bn0703qF/BeIpIzYChD6gCX3f
7q1cJGX+R6HAqGeK7k97cNhX1WEooobFPe/oaJtpj0u3td0jhf/9uJ6G6Jv6Ro=
    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:

```python
#!/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
```

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

---

**Accounting**

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

- The `aaaSessionLR` MO tracks user account login and logout sessions on the APIC and switches, and token refresh. The ACI fabric session alert feature stores information such as the following:
  - Username
  - IP address initiating the session
  - Type (telnet, https, REST etc.)
  - 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 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 MO 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 APIC shards. Once 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 an APIC cluster node, the event logs are lost; event logs are not replicated across the cluster.

The aaaModLR and aaaSessionLR MOs 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 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 MO query data. There is no default policy to export this data.

There are no pre-configured queries in the 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 APIC can be configured to collect byte count and packet count billing statistics from a port configured for routed connectivity to external networks (an l3extInstP EPG) as a shared service. Any EPG in any tenant can share an l3extInstP EPG for routed connectivity to external networks. Billing statistics can be collected for each EPG in any tenant that uses an l3extInstP EPG as a shared service. The leaf switch where the l3extInstP is provisioned forwards the billing statistics to the APIC where they are aggregated. Accounting policies can be configured to periodically export these billing statistics to a server.