Route Control with Route Maps and Route Profiles

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Route Control Profile Policies

The ACI fabric also supports the route-map set clauses for the routes that are advertised into and out of the fabric. The route-map set rules are configured with the Route Control Profile policies and the Action Rule Profiles.

Note The ACI fabric only supports the use of route map related policies, such as match and set rules, within the tenant they were created in. If a route map related policy is created in the common tenant then it is only supported for use in the common tenant.

ACI supports the following set options:

Table 1: Action Rule Profile Properties (route-map set clauses)

Property	OSPF	EIGRP	BGP	Comments
Set Community			Yes	Supports regular and extended communities.
Set Additional Community			Yes	Supports regular and extended communities.

Property	OSPF	EIGRP	BGP	Comments
Route Tag	Yes	Yes		Supported only for BD subnets. Transit prefixes are always assigned the tag 4294967295.
Preference			Yes	Sets BGP local preference.
Metric	Yes		Yes	Sets MED for BGP. Will change the metric for EIGRP but you cannot specify the EIGRP composite metric.
Metric Type	Yes			OSPF Type-1 and OSPF Type-2.

The Route Profile Polices are created under the Layer 3 Outside connection. A Route Control Policy can be referenced by the following objects:

- Tenant BD Subnet
- Tenant BD
- External EPG
- External EPG import/export subnet

Here is an example of using Import Route Control for BGP and setting the local preference for an external route learned from two different Layer 3 Outsides. The Layer 3 Outside connection for the external connection to AS300 is configured with the Import Route Control enforcement. An action rule profile is configured to set the local preference to 200 in the Action Rule Profile for Local Preference window.

The Layer 3 Outside connection External EPG is configured with a 0.0.0.0/0 import aggregate policy to allow all the routes. This is necessary because the import route control is enforced but any prefixes should not be blocked. The import route control is enforced to allow setting the local preference. Another import subnet 151.0.1.0/24 is added with a Route Profile that references the Action Rule Profile in the External EPG settings for Route Control Profile window.

Use the **show ip bgp vrf overlay-1** command to display the MP-BGP table. The MP-BGP table on the spine displays the prefix 151.0.1.0/24 with local preference 200 and a next hop of the border leaf for the BGP 300 Layer 3 Outside connection.

There are two special route control profiles—default-import and default-export. If the user configures using the names default-import and default-export, then the route control profile is automatically applied at the Layer3 outside level for both import and export. The default-import and default-export route control profiles cannot be configured using the 0.0.0.0/0 aggregate.

A route control profile is applied in the following sequential order for fabric routes:

1. Tenant BD subnet

2. Tenant BD
3. Layer3 outside

The route control profile is applied in the following sequential order for transit routes:

1. External EPG prefix
2. External EPG
3. Layer3 outside

About Route Control Per BGP Peer

Route control policies determine what routes are advertised out to the external network (export) or allowed into the fabric (import). For Cisco APIC releases before Release 4.2(1), you configure these policies at the L3Out level, under the L3Out profile (l3extInstP) or through the L3Out subnet under the L3Out (l3extSubnet), so those policies apply to protocols configured for all nodes or paths included in the L3Out. With this configuration, there could be multiple node profiles configured in the L3Out, and each could have multiple nodes or paths with the BGP neighbor specified. Because of this, there is no way to apply individual policies to each protocol entity.

Beginning with Cisco APIC Release 4.2(1), the route control per BGP peer feature is introduced to begin to address this situation, where more granularity in route export and import control is needed.

Guidelines and Restrictions for Route Control Per BGP Peer

Following are the guidelines and restrictions for the route control per BGP peer feature:

- You must configure route profiles used per BGP peer under a tenant.
- The methods to configure route map match, set rule or route profile, and the behavior of each of those components, do not change from previous releases.
- The route profile for this feature can only be set to **Match Routing Policy Only** (global policy), where the route profile is the only source of information to generate the per BGP peer route map. You cannot set the route profile for this feature to **Match Prefix and Routing Policy**.
- A route profile with the **Match Prefix and Routing Policy** type must have a match prefix or external subnet.
- In addition, you must explicitly specify the BD subnets in the prefix list if you want them to be exported.
- You can only associate one route-control profile with a BGP peer for a particular direction.
- Default policy is not supported for these route-maps (only a named route profile can be applied to a BGP peer).
- If you specify a route-control profile for a BGP peer, then a route-map will be generated solely based on that information. Any route-control profile configured in the L3Out profile (l3extInstP) or through the L3Out subnet under the L3Out (l3extSubnet) will not contribute to this route-map. Similarly, if there is no per BGP peer route-control profile configuration, then the route-control profiles under the L3Out will take effect.

- If you specify a private BD subnet in the match prefix list, then it will be included. You do not have to go through additional configurations to exclude private BD subnets.
- If you configure 0.0.0.0/0 in the match prefix list, then it will match all prefixes, including BD subnets.
- Cisco APIC creates and deploys the route-map on border leaf switches with <tenant name>_<route profile name>_<L3Out name>-<direction>. For example, a route map with these settings:
  - **Tenant name**: t1
  - **Route profile name**: rp1
  - **L3Out name**: l3out1
  - **Direction**: import

  will have this as the route map name: **t1_rp1_l3out1-in**
- The character limit for route maps under BGP peer connectivity profile (per-peer route maps) is less than 135.

  ```
  (Tenant Name) + (L3Out Name) + (Route Profile Name) + (Route Profile Context Name) +
  (Route Profile Match Rule Name) + (BGP Peer IP Address) < 135 characters
  ```
- Configuring the route control per BGP peer feature should not affect the behavior of the shared service route-map.
- Keep the following considerations in mind when upgrading or downgrading the APIC software:
  - **Upgrading the APIC software**: If you configured route profiles in the L3Out before upgrading the APIC software, then the route profiles in the L3Out will continue to behave normally until you configure a per BGP peer route profile, at which point the normal guideline and restrictions listed above would apply.
  - **Downgrading the APIC software**: If you configure a per BGP peer route profile and you want to downgrade the APIC software afterwards, you must remove the policy before proceeding with the downgrade.
- The behavior of the permit and deny entries in a route control profile is not deterministic when the order is the same. When you map a route control profile to **instp** or BGP per peer, the order of entries determines their behavior. To ensure that you have a predictable behavior, specify a lower order to the entry that needs to be installed first and a higher order to the one that needs to be installed later.

Configuring Route Control Per BGP Peer Using the GUI

The following procedure describes how to configure the route control per BGP peer feature using the GUI.

Before you begin

- Configure the node, port, functional profile, AEP, and Layer 3 domain.
- Configure a BGP Route Reflector policy to propagate the routes within the fabric.

Procedure

Step 1 Create the tenant and VRF:

a) On the menu bar, choose **Tenants** > **Add Tenant**.

The **Create Tenant** dialog box appears.

b) In the **Name** field, enter the tenant name.
c) In the **VRF Name** field, enter the VRF name.
d) Click **Submit**.

Step 2 Create a bridge domain:

a) In the **Navigation** pane, expand **Tenant** and **Networking**.
b) Right-click **Bridge Domains** and choose **Create Bridge Domain**.
c) In the **Name** field, enter a name for the bridge domain (BD).
d) (Optional) Click the box for **Advertise Host Routes** to enable advertisement to all deployed border leafs.
e) In the **VRF** field, from the drop-down list, choose the VRF you created (v1 in this example).
f) Click **Next**.
g) Click the + icon on **Subnets**.
h) In the **Gateway IP** field, enter the subnet for the BD.
i) In the **Scope** field, choose **Advertised Externally**.

Add the **L3 Out for Route Profile** later, after you create it.

Note
If **Advertise Host Routes** is enabled, the route-map also matches all host routes.

j) Click **OK**.
k) Click **Next** and click **Finish**.

Step 3 Create an application EPG:

a) Right-click **Application Profiles** and choose **Create Application Profile**.
b) Enter a name for the application.
c) Click the + icon for EPGs.
d) Enter a name for the EPG.
e) From the BD drop-down list, choose the bridge domain you previously created.
f) Click **Update**.
g) Click **Submit**.

Step 4 Create a tenant level route-map that will be used as the BGP Per Peer Route-Map:

a) In the **Navigation** pane, expand the **Tenants** > ***Tenant_name*** > **Policies** > **Protocol**.
b) Right-click on **Route Maps for Route Control** and select **Create Route Maps for Route Control**.
c) In the **Create Route Maps for Route Control** dialog box, in the **Name** field, enter a route profile name.
d) In the **Type** field, you must choose **Match Routing Policy Only**.
e) In the **Contexts** area, click the + sign to open the **Create Route Control Context** dialog box and perform the following actions:

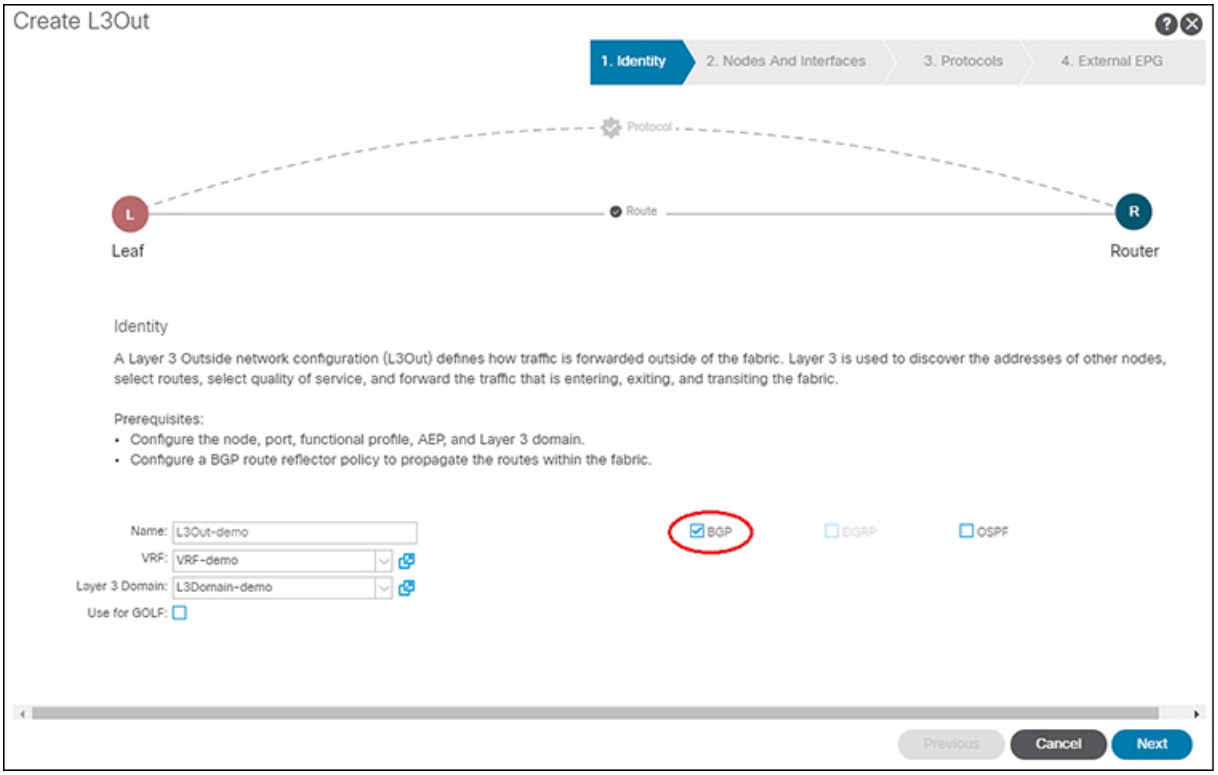
1. Populate the **Order** and the **Name** fields as desired.

2. In the **Match Rule** field, click **Create Match Rule**.
3. In the **Create Match Rule** dialog box, in the **Name** field, enter a name for the match rule.
4. Enter the necessary information in the appropriate fields (**Match Regex Community Terms**, **Match Community Terms**, **Match AS Path Regex Terms** , and **Match Prefix**), then click **Submit**.
5. In the **Set Rule** field, click **Create Set Rules for a Route Map**
6. In the **Create Set Rules for a Route Map** dialog box, in the **Name** field, enter a name for the action rule profile.
7. Choose the desired attributes, and related community, criteria, tags, and preferences. Click **Finish**.
8. In the **Create Route Control Context** window, click **OK**.
9. In the **Create Route Maps for BGP Dampening, Inter-leak** dialog box, click **Submit**.

Step 5 Create the L3Out and configure the BGP for the L3Out:

a) On the **Navigation** pane, expand **Tenant** and **Networking**.
b) Right-click **L3Outs** and choose **Create L3Out**.
c) Enter the necessary information to configure BGP for the L3Out.

You will select **BGP** in the **Identity** page in the L3Out creation wizard to configure the BGP protocol for this L3Out.



d) Continue through the remaining pages (**Nodes and Interfaces**, **Protocols**, and **External EPG**) to complete the configuration for the L3Out.

Step 6 After you have completed the L3Out configuration, configure the route control per BGP peer feature:

a) Navigate to the BGP Peer Connectivity Profile screen:

Tenants > ***tenant*** > **Networking** > **L3Outs** > ***L3out-name*** > **Logical Node Profiles** > ***logical-node-profile-name*** > **Logical Interface Profiles** > ***logical-interface-profile-name*** > **BGP Peer Connectivity Profile** ***IP-address***

b) Scroll down to the **Route Control Profile** field, then click + to configure the following:

- **Name**: Select the route-map that you configured in Step 4, on page 5.
- **Direction**: Choose one of the following options:
  - **Route Import Policy**
  - **Route Export Policy**

Route Maps/Profiles with Explicit Prefix Lists

About Route Map/Profile

The route profile is a logical policy that defines an ordered set (rtctrlCtxP) of logical match action rules with associated set action rules. The route profile is the logical abstract of a route map. Multiple route profiles can be merged into a single route map. A route profile can be one of the following types:

- Match Prefix and Routing Policy: Pervasive subnets (fvSubnet) and external subnets (l3extSubnet) are combined with a route profile and merged into a single route map (or route map entry). Match Prefix and Routing Policy is the default value.
- Match Routing Policy Only: The route profile is the only source of information to generate a route map, and it will overwrite other policy attributes.

Note When explicit prefix list is used, the type of the route profile should be set to "match routing policy only".

After the match and set profiles are defined, the route map must be created in the Layer 3 Out. Route maps can be created using one of the following methods:

- Create a "default-export" route map for export route control, and a "default-import" route map for import route control.
- Create other route maps (not named default-export or default-import) and setup the relation from one or more l3extInstPs or subnets under the l3extInstP.
- In either case, match the route map on explicit prefix list by pointing to the rtctrlSubjP within the route map.

In the export and import route map, the set and match rules are grouped together along with the relative sequence across the groups (rtctrlCtxP). Additionally, under each group of match and set statements (rtctrlCtxP) the relation to one or more match profiles are available (rtctrlSubjP).

Any protocol enabled on Layer 3 Out (for example BGP protocol), will use the export and import route map for route filtering.

About Explicit Prefix List Support for Route Maps/Profile

In Cisco APIC, for public bridge domain (BD) subnets and external transit networks, inbound and outbound route controls are provided through an explicit prefix list. Inbound and outbound route control for Layer 3 Out is managed by the route map/profile (rtctrlProfile). The route map/profile policy supports a fully controllable prefix list for Layer 3 Out in the Cisco ACI fabric.

The subnets in the prefix list can represent the bridge domain public subnets or external networks. Explicit prefix list presents an alternate method and can be used instead of the following:

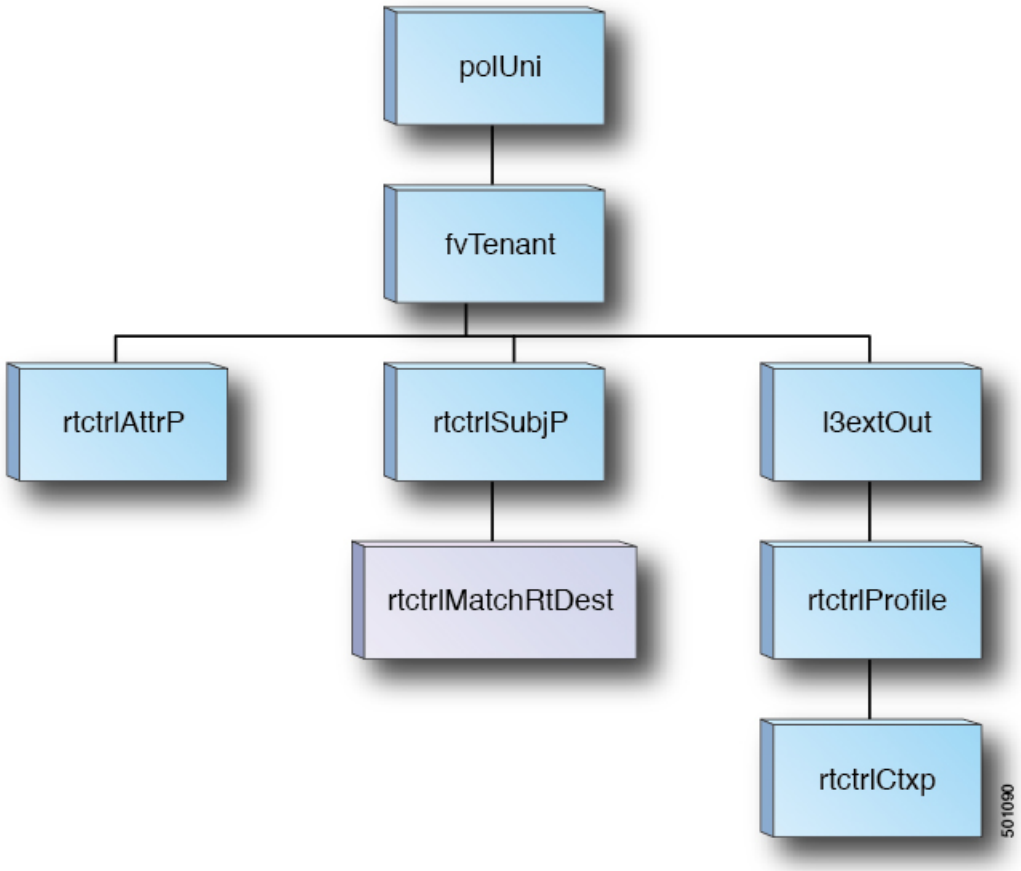
- Advertising BD subnets through BD to Layer 3 Out relation.

Note The subnet in the BD must be marked public for the subnet to be advertised out.

- Specifying a subnet in the l3extInstP with export/import route control for advertising transit and external networks.

Explicit prefix list is defined through a new match type that is called match route destination (rtctrlMatchRtDest). An example usage is provided in the API example that follows.

Figure 1: External Policy Model of API



Additional information about match rules, set rules when using explicit prefix list are as follows:

Match Rules

- Under the tenant (fvTenant), you can create match profiles (rtctrlSubjP) for route map filtering. Each match profile can contain one or more match rules. Match rule supports multiple match types. Prior to Cisco APIC release 2.1, match types supported were explicit prefix list and community list.

  Beginning with Cisco APIC release 2.1, explicit prefix match or match route destination (rtctrlMatchRtDest) is supported.

  Match prefix list (rtctrlMatchRtDest) supports one or more subnets with an optional aggregate flag. Aggregate flags are used for allowing prefix matches with multiple masks starting with the mask mentioned in the configuration till the maximum mask allowed for the address family of the prefix . This is the equivalent of the "le " option in the prefix-list in NX-OS software (example, 10.0.0.0/8 le 32).

  The prefix list can be used for covering the following cases:

  - Allow all (0.0.0.0/0 with aggregate flag, equivalent of 0.0.0.0/0 le 32)
  - One or more of specific prefixes (example: 10.1.1.0/24)
  - One or more of prefixes with aggregate flag (example, equivalent of 10.1.1.0/24 le 32).

Note When a route map with a match prefix "0.0.0.0/0 with aggregate flag" is used under an L3Out EPG in the export direction, the rule is applied only for redistribution from dynamic routing protocols. Therefore, the rule is not applied to the following (in routing protocol such as OSPF or EIGRP):

- Bridge domain (BD) subnets
- Directly connected subnets on the border leaf switch
- Static routes defined on the L3Out

- The explicit prefix match rules can contain one or more subnets, and these subnets can be bridge domain public subnets or external networks. Subnets can also be aggregated up to the maximum subnet mask (/32 for IPv4 and /128 for IPv6).
- When multiple match rules of different types are present (such as match community and explicit prefix match), the match rule is allowed only when the match statements of all individual match types match. This is the equivalent of the AND filter. The explicit prefix match is contained by the subject profile (rtctrlSubjP) and will form a logical AND if other match rules are present under the subject profile.
- Within a given match type (such as match prefix list), at least one of the match rules statement must match. Multiple explicit prefix match (rtctrlMatchRtDest) can be defined under the same subject profile (rtctrlSubjP) which will form a logical OR.
- When a per-peer route-map is configured with a permit-all rule followed by an exact match rule, then any specific properties that were set in the exact match rule may not be processed.
- If an empty route in a route map is matched with action permit or deny without a match clause, all the routes will be either permitted or denied. A regular route map for import or export route control does not permit an empty route. Beginning with Cisco APIC release 5.2(4) , static and direct routes will not permit routes without any route matches.

Enhancements for Match Prefix

Beginning with Cisco APIC release 4.2(3), two new fields are now available in the Match Prefix field when you create a match rule and you enable aggregation. Based on the release, these fields have a different naming conventions as outlined in the table below.

Release	Field
Cisco APIC release 4.2(3)	**From Prefix**
	To Prefix
Cisco APIC release 5.2(2)	**Greater Than Mask**
	Less Than Mask
Cisco APIC release 5.2(6)	**Greater Equal Mask**
	Less Equal Mask

Use these fields to specify the mask range when you create a prefix match rule and enable aggregation. Following are example situations where you might use these fields:

- Allow all (0.0.0.0/0 with mask length between 24 to 30, the equivalent of 0.0.0.0/0 ge 24 le 30)
- Prefixes with a specific IP address and a netmask greater than 28 (for example, the equivalent of 10.1.1.0/24 ge 28)

The following table provides more information on the various scenarios where you might use these two new fields and the result for each scenario. Note the following:

- The **Greater Equal Mask** and **Less Equal Mask** fields are available only if you select the **Aggregate** option in the **Create Match Route Destination Rule** window.
- A value of **0** in the **Greater Equal Mask** and **Less Equal Mask** fields is considered **unspecified** and assumes the following default values:
  - Greater Equal Mask=0
  - Less Equal Mask=32 or 128, depending on whether the IP address family is IPv4 or IPv6.

  This situation assumes legacy behavior and provides support for importing old configurations where these properties are missing. Refer to the second row in the following table for more information.

IP Address/Netmask	Aggregate	Greater Equal Mask Entry (fromPfxLen)	Less Equal Mask Entry (toPfxLen)	Result	Additional Information
192.0.2.0/24	Not enabled	N/A	N/A	192.0.2.0/24	Exact match
192.0.2.0/24	Enabled	0	0	192.0.2.0/24 le 32	Legacy behavior
192.0.2.0/24	Enabled	24	Irrelevant value (error occurs because of value provided in **Greater Equal Mask** entry)	**ERROR:** Invalid configuration.	The **Greater Equal Mask** entry must be larger than the netmask length.
192.0.2.0/24	Enabled	28	30	192.0.2.0/24 **ge 28 le 30**	New behavior with these new fields
192.0.2.0/24	Enabled	30	0	192.0.2.0/24 **ge 30**	New behavior with these new fields
192.0.2.0/24	Enabled	28	28	192.0.2.0/24 **eq 28**	New behavior with these new fields
192.0.2.0/24	Enabled	0	28	192.0.2.0/24 **le 28**	New behavior with these new fields

IP Address/Netmask	Aggregate	Greater Equal Mask Entry (fromPfxLen)	Less Equal Mask Entry (toPfxLen)	Result	Additional Information
192.0.2.0/24	Enabled	30	28	**ERROR:** Invalid configuration.	The **Greater Equal Mask** entry cannot be larger than the **Less Equal Mask** entry.

Set Rules

Set policies must be created to define set rules that are carried with the explicit prefixes such as set community and set tag.

Aggregation Support for Explicit Prefix List

Each prefix (rtctrlMatchRtDest) in the match prefixes list can be aggregated to support multiple subnets matching with one prefix list entry.

Aggregated Prefixes and BD Private Subnets

Although subnets in the explicit prefix list match may match the BD private subnets using aggregated or exact match, private subnets will not be advertised through the routing protocol using the explicit prefix list. The scope of the BD subnet must be set to "public" for the explicit prefix list feature to advertise the BD subnets.

Differences in Behavior for 0.0.0.0/0 with Aggregation

The 0.0.0.0/0 with Aggregate configuration creates an IP prefix-list equivalent to “0.0.0.0/0 le 32”. The 0.0.0.0/0 with Aggregate configuration can be used mainly in two situations:

- “Export Route Control Subnet” with “Aggregate Export” scope in L3Out subnet under the L3Out network (L3Out EPG)
- An explicit prefix-list (Match Prefix rule) assigned to a route map with the name “default-export”

When used with the “Export Route Control Subnet” scope under the L3Out subnet, the route map will only match routes learned from dynamic routing protocols. It will not match BD subnets or directly-connected networks.

When used with the explicit route map configuration, the route map will match all routes, including BD subnets and directly-connected networks.

Consider the following examples to get a better understanding of the expected and unexpected (inconsistent) behavior in the two situations described above.

Scenario 1

For the first scenario, we configure a route map (with a name of `rpm_with_catch_all`) using a configuration post similar to the following:

```
<l3extOut annotation="" descr="" dn="uni/tn-t9/out-L3-out" enforceRtctrl="export"
name="L3-out" nameAlias="" ownerKey="" ownerTag="" targetDscp="unspecified">
```

```
   <rtctrlProfile annotation="" descr="" name="rpm_with_catch_all" nameAlias="" ownerKey=""
 ownerTag="" type="combinable">
        <rtctrlCtxP action="permit" annotation="" descr="" name="catch_all" nameAlias=""
order="0">
            <rtctrlScope annotation="" descr="" name="" nameAlias="">
                <rtctrlRsScopeToAttrP annotation="" tnRtctrlAttrPName="set_metric_type"/>
            </rtctrlScope>
        </rtctrlCtxP>
    </rtctrlProfile>
    <ospfExtP annotation="" areaCost="1" areaCtrl="redistribute,summary" areaId="backbone"
 areaType="regular" descr="" multipodInternal="no" nameAlias=""/>
    <l3extRsEctx annotation="" tnFvCtxName="ctx0"/>
   <l3extLNodeP annotation="" configIssues="" descr="" name="leaf" nameAlias="" ownerKey=""
 ownerTag="" tag="yellow-green" targetDscp="unspecified">
       <l3extRsNodeL3OutAtt annotation="" configIssues="" rtrId="20.2.0.2" rtrIdLoopBack="no"
 tDn="topology/pod-1/node-104">
          <l3extLoopBackIfP addr="14.1.1.1/32" annotation="" descr="" name="" nameAlias=""/>

            <l3extInfraNodeP annotation="" descr="" fabricExtCtrlPeering="no"
fabricExtIntersiteCtrlPeering="no" name="" nameAlias="" spineRole=""/>
        </l3extRsNodeL3OutAtt>
        <l3extLIfP annotation="" descr="" name="interface" nameAlias="" ownerKey=""
ownerTag="" tag="yellow-green">
            <ospfIfP annotation="" authKeyId="1" authType="none" descr="" name=""
nameAlias="">
                <ospfRsIfPol annotation="" tnOspfIfPolName=""/>
            </ospfIfP>
            <l3extRsPathL3OutAtt addr="36.1.1.1/24" annotation="" autostate="disabled"
descr="" encap="vlan-3063" encapScope="local" ifInstT="ext-svi" ipv6Dad="enabled" llAddr="::"
 mac="00:22:BD:F8:19:FF" mode="regular" mtu="inherit"
tDn="topology/pod-1/paths-104/pathep-[accBndlGrp_104_pc13]" targetDscp="unspecified"/>
            <l3extRsNdIfPol annotation="" tnNdIfPolName=""/>
            <l3extRsIngressQosDppPol annotation="" tnQosDppPolName=""/>
            <l3extRsEgressQosDppPol annotation="" tnQosDppPolName=""/>
        </l3extLIfP>
    </l3extLNodeP>
    <l3extInstP annotation="" descr="" exceptionTag="" floodOnEncap="disabled"
matchT="AtleastOne" name="epg" nameAlias="" prefGrMemb="exclude" prio="unspecified"
targetDscp="unspecified">
        <l3extRsInstPToProfile annotation="" direction="export"
tnRtctrlProfileName="rpm_with_catch_all"/>
       <l3extSubnet aggregate="" annotation="" descr="" ip="0.0.0.0/0" name="" nameAlias=""
 scope="import-security"/>
        <fvRsCustQosPol annotation="" tnQosCustomPolName=""/>
    </l3extInstP>
</l3extOut>


<rtctrlAttrP annotation="" descr="" dn="uni/tn-t9/attr-set_metric_type" name="set_metric_type"
 nameAlias="">
   <rtctrlSetRtMetricType annotation="" descr="" metricType="ospf-type1" name="" nameAlias=""
 type="metric-type"/>
</rtctrlAttrP>


<rtctrlSubjP annotation="" descr="" dn="uni/tn-t9/subj-catch_all_ip" name="catch_all_ip"
nameAlias="">
    <rtctrlMatchRtDest aggregate="yes" annotation="" descr="" ip="0.0.0.0/0" name=""
nameAlias=""/>
</rtctrlSubjP>
```

With this route map, what we would expect with 0.0.0.0/0 is that all the routes would go with the property `metricType="ospf-type1"`, but only for the OSPF route.

In addition, we also have a subnet configured under a bridge domain (for example, 209.165.201.0/27), with a bridge domain to L3Out relation, using a route map with a pervasive subnet (fvSubnet) for a static route. However, even though the route map shown above is combinable, we do not want it applied for the subnet configured under the bridge domain, because we want 0.0.0.0/0 in the route map above to apply only for the transit route, not on the static route.

Following is the output for the `show route-map` and `show ip prefix-list` commands, where `exp-ctx-st-2555939` is the name of the outbound route map for the subnet configured under the bridge domain, and the name of the prefix list is provided within the output from the `show route-map` command:

```
leaf4# show route-map exp-ctx-st-2555939
route-map exp-ctx-st-2555939, deny, sequence 1
  Match clauses:
    tag: 4294967295
  Set clauses:
route-map exp-ctx-st-2555939, permit, sequence 15801
  Match clauses:
    ip address prefix-lists: IPv4-st16391-2555939-exc-int-inferred-export-dst
    ipv6 address prefix-lists: IPv6-deny-all
  Set clauses:

leaf4# show ip prefix-list IPv4-st16391-2555939-exc-int-inferred-export-dst
ip prefix-list IPv4-st16391-2555939-exc-int-inferred-export-dst: 1 entries
   seq 1 permit 209.165.201.0/27

leaf4#
```

In this situation, everything behaves as expected, because when the bridge domain subnet goes out, it is not applying the `rpm_with_catch_all` route map policies.

Scenario 2

For the second scenario, we configure a "default-export" route map for export route control, where an explicit prefix-list (Match Prefix rule) is assigned to the "default-export" route map, using a configuration post similar to the following:

```
<l3extOut annotation="" descr="" dn="uni/tn-t9/out-L3-out" enforceRtctrl="export"
name="L3-out" nameAlias="" ownerKey="" ownerTag="" targetDscp="unspecified">
    <rtctrlProfile annotation="" descr="" name="default-export" nameAlias="" ownerKey=""
ownerTag="" type="combinable">
        <rtctrlCtxP action="permit" annotation="" descr="" name="set-rule" nameAlias=""
order="0">
            <rtctrlScope annotation="" descr="" name="" nameAlias="">
                <rtctrlRsScopeToAttrP annotation="" tnRtctrlAttrPName="set_metric_type"/>
            </rtctrlScope>
        </rtctrlCtxP>
    </rtctrlProfile>
    <ospfExtP annotation="" areaCost="1" areaCtrl="redistribute,summary" areaId="backbone"
 areaType="regular" descr="" multipodInternal="no" nameAlias=""/>
    <l3extRsEctx annotation="" tnFvCtxName="ctx0"/>
   <l3extLNodeP annotation="" configIssues="" descr="" name="leaf" nameAlias="" ownerKey=""
 ownerTag="" tag="yellow-green" targetDscp="unspecified">
      <l3extRsNodeL3OutAtt annotation="" configIssues="" rtrId="20.2.0.2" rtrIdLoopBack="no"
 tDn="topology/pod-1/node-104">
          <l3extLoopBackIfP addr="14.1.1.1/32" annotation="" descr="" name="" nameAlias=""/>

            <l3extInfraNodeP annotation="" descr="" fabricExtCtrlPeering="no"
fabricExtIntersiteCtrlPeering="no" name="" nameAlias="" spineRole=""/>
        </l3extRsNodeL3OutAtt>
        <l3extLIfP annotation="" descr="" name="interface" nameAlias="" ownerKey=""
```

```
ownerTag="" tag="yellow-green">
            <ospfIfP annotation="" authKeyId="1" authType="none" descr="" name=""
nameAlias="">
                <ospfRsIfPol annotation="" tnOspfIfPolName=""/>
            </ospfIfP>
            <l3extRsPathL3OutAtt addr="36.1.1.1/24" annotation="" autostate="disabled"
descr="" encap="vlan-3063" encapScope="local" ifInstT="ext-svi" ipv6Dad="enabled" llAddr="::"
 mac="00:22:BD:F8:19:FF" mode="regular" mtu="inherit"
tDn="topology/pod-1/paths-104/pathep-[accBndlGrp_104_pc13]" targetDscp="unspecified"/>
            <l3extRsNdIfPol annotation="" tnNdIfPolName=""/>
            <l3extRsIngressQosDppPol annotation="" tnQosDppPolName=""/>
            <l3extRsEgressQosDppPol annotation="" tnQosDppPolName=""/>
        </l3extLIfP>
    </l3extLNodeP>
    <l3extInstP annotation="" descr="" exceptionTag="" floodOnEncap="disabled"
matchT="AtleastOne" name="epg" nameAlias="" prefGrMemb="exclude" prio="unspecified"
targetDscp="unspecified">
       <l3extSubnet aggregate="" annotation="" descr="" ip="0.0.0.0/0" name="" nameAlias=""
 scope="import-security"/>
        <fvRsCustQosPol annotation="" tnQosCustomPolName=""/>
    </l3extInstP>
</l3extOut>
```

Notice that this `default-export` route map has similar information as the `rpm_with_catch_all` route map, where the IP is set to 0.0.0.0/0 (`ip=0.0.0.0/0`), and the set rule in the `default-export` route map is configured only with the Set Metric Type (`tnRtctrlAttrPName=set_metric_type`).

Similar to the situation in the previous example, we also have the same subnet configured under the bridge domain, with a bridge domain to L3Out relation, as we did in the previous example.

However, following is the output in this scenario for the `show route-map` and `show ip prefix-list` commands:

```
leaf4# show route-map exp-ctx-st-2555939
route-map exp-ctx-st-2555939, deny, sequence 1
  Match clauses:
    tag: 4294967295
  Set clauses:
route-map exp-ctx-st-2555939, permit, sequence 8201
  Match clauses:
    ip address prefix-lists:
IPv4-st16391-2555939-exc-int-out-default-export2set-rule0pfx-only-dst
    ipv6 address prefix-lists: IPv6-deny-all
  Set clauses:
    metric-type type-1

leaf4# show ip prefix-list IPv4-st16391-2555939-exc-int-inferred-export-dst
% Policy IPv4-st16391-2555939-exc-int-inferred-export-dst not found
ifav82-leaf4# show ip prefix-list
IPv4-st16391-2555939-exc-int-out-default-export2set-rule0pfx-only-dst
ip prefix-list IPv4-st16391-2555939-exc-int-out-default-export2set-rule0pfx-only-dst: 1
entries
   seq 1 permit 209.165.201.0/27

leaf4#
```

Notice that in this situation, when the bridge domain subnet goes out, it is applying the `default-export` route map policies. In this situation, that route map matches all routes, including BD subnets and directly-connected networks. This is inconsistent behavior.

Guidelines and Limitations

- You must choose one of the following two methods to configure your route maps. If you use both methods, it will result in double entries and undefined route maps.
  - Add routes under the bridge domain (BD) and configure a BD to Layer 3 Outside relation
  - Configure the match prefix under rtctrlSubjP match profiles.
- The character limit for route maps under L3Out is less than 93.

  ```
  (Route Profile Name) + (Route Profile Context Name) + (Route Profile Match Rule Name)
  < 93 characters
  ```
- **deny-static** implicit entry is not supported on Export Route Map. You need to explicitly configure the permit and deny entries required to control the export of static routes.
- Route-map per peer in an L3Out is not supported for OSPF and EIGRP. Route-map can only be applied on L3Out as a whole. Route-map per peer in an L3Out is supported for BGP.

  Following are possible workarounds to this issue:
  - Block the prefix from being advertised from the other side of the neighbor.
  - Block the prefix on the route-map on the existing L3Out where you don't want to learn the prefix, and move the neighbor to another L3Out where you want to learn the prefix and create a separate route-map.
- Creating route-maps using a mixture of GUI and API commands is not supported. As a possible workaround, you can create a route-map different from the default route-map using the GUI, but the route-map created through the GUI on an L3Out cannot be applied to per-peer.

Configuring a Route Map/Profile with Explicit Prefix List Using the GUI

Before you begin

- Tenant and VRF must be configured.
- The VRF must be enabled on the leaf switch.

Procedure

Step 1 On the menu bar, click **Tenant**, and in the **Navigation** pane, expand *Tenant_name* > **Policies** > **Protocol** > **Match Rules**.

Step 2 Right click **Match Rules**, and click **Create Match Rule for a Route Map**.

Step 3 In the **Create Match Rule** window, enter a name for the rule and choose the desired community terms.

Step 4 Enter the necessary information for the match prefix.

The method that you use to enter information for the match prefix varies, depending on the APIC release.

- For APIC releases prior to 4.2(3), in the **Create Match Rule** window, expand **Match Prefix** and perform the following actions:

a. In the **IP** field, enter the explicit prefix list.

   The explicit prefix can denote a BD subnet or an external network.

b. (Optional) In the **Description** field, enter descriptive information about the route destination policy.

c. Check the **Aggregate** check box only if you desire an aggregate prefix.

d. Click **Update**.

- For APIC releases 4.2(3) and later, in the **Create Match Rule** window, click **+** in the **Match Prefix** area.

  The **Create Match Route Destination Rule** window appears. Perform the following actions in this window:

  a. In the **IP** field, enter the explicit prefix list.

     The explicit prefix can denote a BD subnet or an external network.

  b. (Optional) In the **Description** field, enter descriptive information about the route destination policy.

  c. Determine if you want an aggregate prefix or not.

     - If you do not want an aggregate prefix, leave the **Aggregate** unchecked and click **Submit**, then go to Step 5, on page 17.
     - If you want an aggregate prefix, check the **Aggregate** check box.

       The **Greater Equal Mask** and **Less Equal Mask** fields become available.

       1. In the **Greater Equal Mask** field, specify the prefix length to match.

          The range is from 0 to 128. A value of 0 is considered unspecified.

       2. In the **Less Equal Mask** field, specify the prefix length to match.

          The range is from 0 to 128. A value of 0 is considered unspecified.

       See Enhancements for Match Prefix, on page 10 for more information on the **Greater Equal Mask** and **Less Equal Mask** fields for APIC releases 4.2(3) and later.

  d. Click **Submit** in the **Create Match Route Destination Rule** window.

Step 5 In the **Create Match Rule** window, click **Submit**.

The match rule can have one or more of the match destination rules and one or more match community terms. Across the match types, the AND filter is supported, so all conditions in the match rule must match for the route match rule to be accepted. When there are multiple match prefixes in **Match Destination Rules**, the OR filter is supported. Any one match prefix is accepted as a route type if it matches.

Step 6 Under **L3Outs**, click and choose the available default layer 3 out.

If you desire another layer 3 out, you can choose that instead.

Step 7 Right-click **Route map for import and export route control**, and click **Create Route map for import and export route control**.

Step 8 In the **Create Route map for import and export route control** dialog box, use a default route map, or enter a name for the desired route map.

For the purpose of this example, we use **default_export** route map.

Step 9 In the **Type** field, choose **Match Routing Policy Only**.

The Match Routing policy is the global RPC match destination route. The other option in this field is Match Prefix and Routing Policy which is the combinable RPC match destination route.

Step 10 In the **Contexts** area, expand the + icon to display the **Create Route Control Context** dialog box.

Step 11 Enter a name for route control context, and choose the desired options for each field. To deny routes that match criteria that are defined in the match rule (which you will be choosing in the next step), select the action **deny**. The default action is **permit**.

Step 12 In the **Match Rule** field, choose the rule that was created earlier.

Step 13 In the **Set Rule** field, choose **Create Set Rules for a Route Map**.

Typically in the route map/profile you have a match and so the prefix list is allowed in and out, but in addition some attributes are being set for these routes, so that the routes with the attributes can be matched further.

Step 14 In the **Create Set Rules for a Route Map** dialog box, enter a name for the action rule and check the desired check boxes. Click **Finish**.

Step 15 In the **Create Route Control Context** dialog box, click **OK**. And in the **Create Route map for import and export route control** dialog box, click **Submit**.

This completes the creation of the route map/profile. The route map is a combination of match action rules and set action rules. The route map is associated with export profile or import profile or redistribute profile as desired by the user. You can enable a protocol with the route map.

Routing Control Protocols

About Configuring a Routing Control Protocol Using Import and Export Controls

This topic provides a typical example that shows how to configure a routing control protocol using import and export controls. It assumes that you have configured Layer 3 outside network connections with BGP. You can also perform these tasks for a Layer 3 outside network configured with OSPF.

Configuring a Route Control Protocol to Use Import and Export Controls, With the GUI

This example assumes that you have configured the Layer 3 outside network connections using BGP. It is also possible to perform these tasks for a network configured using OSPF.

This task lists steps to create import and export policies. By default, import controls are not enforced, so the import control must be manually assigned.

Before you begin

- The tenant, private network, and bridge domain are created.
- The Layer 3 outside for tenant networks is created.

Procedure

Step 1 On the menu bar, click **TENANTS** > ***Tenant_name*** > **Networking** > **L3Outs** > ***Layer3_Outside_name*** .

Step 2 Right click *Layer3_Outside_name* and click **Create Route map for import and export route control**.

Step 3 In the **Create Route map for import and export route control** dialog box, perform the following actions:

a) From the **Name** field drop-down list, choose the appropriate route profile.
Depending on your selection, whatever is advertised on the specific outside is automatically used.
b) In the **Type** field, choose **Match Prefix AND Routing Policy**.
c) In the **Contexts** area, click + to bring up the **Create Route Control Context** window.

Step 4 In the **Create Route Control Context** dialog box, perform the following actions:

a) In the **Order** field, choose the desired order number.
b) In the **Name** field, enter a name for the route control private network.
c) From the **Match Rule** field drop-down list, click **Create Match Rule For a Route Map**.
d) In the **Create Match Rule** dialog box, in the **Name** field, enter a route match rule name. Click **Submit**.

Specify the match community regular expression term and match community terms as desired. Match community factors will require you to specify the name, community and scope.

e) From the **Set Rule** drop-down list, choose **Create Set Rules For a Route Map**.
f) In the **Create Set Rules For a Route Map** dialog box, in the **Name** field, enter a name for the rule.
g) Check the check boxes for the desired rules you want to set, and choose the appropriate values that are displayed for the choices. Click **Finish**.
The policy is created and associated with the action rule.
h) In the **Create Route Control Context** window, click **OK**.
i) In the **Create Route map for import and export route control** dialog box, click **Submit**.

Step 5 In the **Navigation** pane, choose **Route Profile** > ***route_profile_name*** > ***route_control_private_network_name*** .
In the **Work** pane, under **Properties** the route profile policy and the associated action rule name are displayed.

Step 6 In the **Navigation** pane, click the ***Layer3_Outside_name*** , then click the **Policy/Main** tabs.
In the **Work** pane, the **Properties** are displayed.

Step 7 (Optional) Next to the **Route Control Enforcement** field, check the **Import** check box to enable the import policy.

The import control policy is not enabled by default but can be enabled by the user. The import control policy is supported for BGP and OSPF, but not for EIGRP. If the user enables the import control policy for an unsupported protocol, it will be automatically ignored. The export control policy is supported for BGP, EIGRP, and OSPF.

Note
If BGP is established over OSPF, then the import control policy is applied only for BGP and ignored for OSPF.

Step 8 To create a customized export policy, right-click **Route map for import and export route control**, click **Create Route map for import and export route control**, and perform the following actions:

a) In the **Create Route map for import and export route control** dialog box, from the drop-down list in the **Name** field, choose or enter a name for the export policy.
b) In the **Contexts** area, click + to bring up the **Create Route Control Context** window.

c) In the **Create Route Control Context** dialog box, in the **Order** field, choose a value.
d) In the **Name** field, enter a name for the route control private network.
e) (Optional) From the **Match Rule** field drop-down list, choose **Create Match Rule For a Route Map**, and create and attach a match rule policy if desired.
f) From the **Set Rule** field drop-down list, choose **Create Set Rules For a Route Map** and click **OK**.
Alternatively, if desired, you can choose an existing set action, and click **OK**
g) In the **Create Set Rules For A Route Map** dialog box, in the **Name** field, enter a name.
h) Check the check boxes for the desired rules you want to set, and choose the appropriate values that are displayed for the choices. Click **Finish**.
In the **Create Route Control Context** dialog box, the policy is created and associated with the action rule.
i) Click **OK**.
j) In the **Create Route map for import and export route control** dialog box, click **Submit**.

In the **Work** pane, the export policy is displayed.

Note
To enable the export policy, it must first be applied. For the purpose of this example, it is applied to all the subnets under the network.

Step 9 In the **Navigation** pane, expand **L3Outs** > ***L3Out_name*** > **External EPGs** > ***externalEPG_name*** , and perform the following actions:

a) Expand **Route Control Profile**.
b) In the **Name** field drop-down list, choose the policy created earlier.
c) In the **Direction** field drop-down list, choose **Route Export Policy**. Click **Update**.

Interleak Redistribution for MP-BGP

Overview of Interleak Redistribution for MP-BGP

This topic provides how to configure an interleak redistribution in the Cisco Application Centric Infrastructure (ACI) fabric using Cisco Application Policy Infrastructure Controller (APIC).

In Cisco ACI, a border leaf node on which Layer 3 Outsides (L3Outs) are deployed redistributes L3Out routes to the BGP IPv4/IPv6 address family and then to the MP-BGP VPNv4/VPNv6 address family along with the VRF information so that L3Out routes are distributed from a border leaf node to other leaf nodes through the spine nodes. Interleak redistribution in the Cisco ACI fabric refers to this redistribution of L3Out routes to the BGP IPv4/IPv6 address family. By default, interleak happens for all L3Out routes, such as routes learned through dynamic routing protocols, static routes, and directly-connected subnets of L3Out interfaces, except for routes learned through BGP. Routes learned through BGP are already in the BGP IPv4/IPv6 table and are ready to be exported to MP-BGP VPNv4/VPNv6 without interleak.

Interleak redistribution allows users to apply a route-map to redistribute L3Out routes selectively into BGP to control which routes should be visible to other leaf nodes, or to set some attributes to the routes, such as BGP community, preference, metric, and so on. This redistribution enables selective transit routing to be performed on another border leaf node based on the attributes set by the ingress border leaf node or so that other leaf nodes can prefer routes from one border leaf node to another.

Applying a route map to interleak redistribution from OSPF and EIGRP routes has been available in earlier releases.

Beginning in the Cisco APIC 4.2(1) release, applying a route map to interleak redistribution from static routes is supported.

Beginning in the Cisco APIC 5.1(4) release, applying a route map to interleak redistribution from direct subnets (L3Out interfaces) is supported. This feature was originally added in the Cisco APIC 4.2(6h) release, but was not available in any of the 5.x releases until the 5.1(4) release.

Beginning in the Cisco APIC 5.1(4) release, you can configure **deny** action in the route-map for interleak redistribution for static routes and direct subnets. This feature was originally added in the Cisco APIC 4.2(6h) release, but was not available in any of the 5.x releases until the 5.1(4) release.

Configuring a Route Map for Interleak Redistribution Using the GUI

Route maps for interleak redistribution can be created under **Tenant** > **Policies** > **Protocol** > **Route Maps for Route Control**.

Before you begin

Create the tenant.

Procedure

Step 1 On the menu bar, click **Tenants**.

Step 2 In the Work pane, double click the tenant's name.

Step 3 In the **Navigation** pane, expand ***tenant_name*** > **Policies** > **Protocol** > **Route Maps for Route Control**.

Step 4 Right-click **Route Maps for Route Control** and click **Create Route Maps for Route Control**. The **Create Route Maps for Route Control** dialog box appears.

Step 5 In the **Name** field, enter a name for the route map to control interleak (redistribution to BGP).

Step 6 In the **Contexts** area, click the **+** sign to open the **Create Route Control Context** dialog box, and perform the following actions:

a) Populate the **Order** and the **Name** fields as desired.
b) In the **Action** field, choose **Permit**.
c) In the **Match Rule** field, choose your desired match rule or create a new one.
d) In the **Set Rule** field, choose your desired set rule or create a new one.
e) Click **OK**.

Repeat this step for each route control context that you need to create.

Step 7 In the **Create Route Maps for Route Control** dialog box, click **Submit**.

Applying a Route Map for Interleak Redistribution Using the GUI

A route map to customize interleak redistribution from a specific L3Out must be applied through the L3Out.

Before you begin

Create the tenant, VRF, and L3Out.

Procedure

Step 1 On the menu bar, click **Tenants**.

Step 2 In the Work pane, double click the tenant's name.

Step 3 In the **Navigation** pane, expand ***tenant_name*** > **Networking** > **L3Outs** > ***L3Out_name***.

Step 4 Click the **Policy** > **Main** tab to access the **Properties** window for this L3Out.

Step 5 For the OSPF or EIGRP routes, perform the following actions:

a) In the **Route Profile for Interleak** field, choose or create a route map/profile.

b) In the Work pane, click **Submit**, then **Submit Changes**.

Step 6 For static routes, perform the following actions:

a) In the **Route Profile for Redistribution** field, click **+** icon.

b) In the **Source** field, choose **static** for static routes as the source for the interleak redistribution.

c) Click **Update**.