

Chapter 7

Creating Hierarchical Policies for Interface Groups

This chapter provides information for configuring policy-based routing management on E-series routers.

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Hierarchical Policies for Interface Groups Overview

Hierarchical policies allow classifier groups and parent groups within a policy to point to line module global parent groups. The line module global parent groups (external parent groups) can point to other external parent groups. Full intra-interface policy hierarchies for all forwarding layer policies allow classified flows within a policy attachment to share bandwidth. Bandwidth-sharing between interfaces uses line module global parent group definitions and interface grouping. However, if you need to share bandwidth between two or more interfaces, rate-limits must be chained beyond a single attachment.

Policies for interface groups include external parent groups that are implicitly instantiated during policy attachment based on each unique interface group encountered.

External Parent Groups

Parent groups act as nonleaf nodes in a hierarchical policy. You can build a hierarchy of policies using classifier groups as leaf nodes and parent groups as parent nodes within a policy list. Each classifier group (with or without a rate limit) can point to a single parent group and that parent group can point to another parent group. To avoid undefined hierarchies, each node can only point to one other node.

The inter-interface hierarchical model includes references to parent groups that are defined externally from a policy list. This enables you to define hierarchical nodes outside the scope of a policy-list attachment. In Global Configuration mode, each external parent group can have a rate-limit profile defined and have a reference to another external parent group.

The classifier groups and parent groups within a policy list can point to external parent groups for all policies that implement hierarchical policies. Each external parent group reference must also have a policy parameter name.

External parent group names are global. Internal parent group names are local to each policy configuration. Because both of these name spaces are different, you can configure overlapping names.

Example: Configuring Hierarchical Policy Parameters

You configure policy parameters in Global Configuration mode. Only hierarchical policy parameters can have external parent group references. Each parameter has a single value, depending on the type of parameter. The hierarchical policy parameter can have a single numeric value or a keyword.

In Interface Configuration mode, you can override the value for a policy parameter for each interface. The value for a parameter configured in Interface Configuration mode supersedes the value configured for the parameter in Global Configuration mode. However, if a parameter is not configured in Interface Configuration mode, the value configured in Global Configuration mode is used.

Each reference to a policy parameter in a policy is substituted with its value for all attachments of this policy at the interface. The value can come from the interface or global configuration for the parameter. Therefore, the value configured for the parameters referenced in policies can be different for attachments at different interfaces. This enables you to have an attachment-specific configuration in a policy list that is deferred until the policy is attached.

There are two types of values that a hierarchical policy parameter can take: numeric and keyword. Keywords are resolved to numeric values during configuration of a policy parameter at the interface.

The following example assigns a value of 10 to policy parameter A in Global Configuration mode.

```
host1(config)#policy-parameter A hierarchical
host1(config-policy-parameter)#aggregation-node 10
host1(config-policy-parameter)#exit
```

The following example assigns value 1 to policy parameter A and value 2 to policy parameter B in Interface Configuration mode. Also, the value configured for parameter A in interface fast3/0.1 overrides the value configured in the previous example.

```
host1(config)#interface fastEthernet 3/0.1
host1(config-interface)#ip policy-parameter hierarchical A 1
host1(config-interface)#ip policy-parameter hierarchical B 2
host1(config-interface)#exit
```

The following example assigns keyword **vlan** to parameter C in Global Configuration mode.

```
host1(config)#policy-parameter C hierarchical
host1(config-policy-parameter)#aggregation-node vlan
host1(config-policy-parameter)#exit
```

The following example assigns keyword **atm-vc** to parameter C in Interface Configuration mode. Policy parameter C is assigned with interface type atm-vc for IP interface at atm3/0.1. The keyword **atm-vc** is resolved to the identifier of the ATM minor interface on which the IP interface atm3/0.1 is stacked.

```
host1(config)#interface atm 3/0.1
host1(config-interface)#ip policy-parameter hierarchical C atm-vc
host1(config-interface)#exit
```

The following keywords are supported: **atm-vc**, **atm-vp**, **atm**, **ethernet**, **vlan**, **svlan**, **fr-vc**, and **forwarding**. Table 12 indicates the mapping of shorthand notation to actual value that are used internally.

Table 12: Shorthand Notation Mapping

Shorthand number	Shorthand	Value	Supported in
1	ATM-VP <i>vpi</i>	Identifier constructed from slot, adapter, port, ATM VP id.	IP, IPv6, L2TP, and MPLS policies
2	ATM-VC	Unique identifier of the ATM minor interface	IP, IPv6, and MPLS policies
3	Ethernet	Unique identifier of Ethernet major interface	IP, IPv6, and MPLS policies
4	VLAN	Unique identifier of VLAN interface	IP, IPv6, and MPLS policies
5	SVLAN <i>id</i>	Identifier constructed from slot, adapter, port, SVLAN ID.	IP, IPv6, L2TP, and MPLS policies
6	FR-VC	Unique identifier of frame relay minor interface	IP, IPv6, and MPLS policies
7	ATM	Unique identifier of ATM major interface	IP, IPv6, and MPLS policies
8	Forwarding	Unique identifier of the forwarding interface where the parameter is configured.	IP, IPv6, L2TP, and MPLS policies

Hierarchical Aggregation Nodes

An internal parent group configured within a policy defines a hierarchical aggregation node template. An attachment of this policy creates an aggregation node for each internal parent group in a policy. Aggregation nodes are scoped within a single attachment and cannot be shared beyond a single attachment. An aggregation node stores a single rate-limit instance and statistics for this rate-limit. Aggregate nodes can be shared between two or more classified flows within a single attachment using the classifier group and parent group association.

Rate-limit aggregation nodes extend beyond a single attachment so classified flows across two or more attachments can reference the same aggregation node to share a single rate-limit instance. You can use external parent groups and policy parameters for sharing aggregate nodes across policy attachments. Each external parent group reference in a policy is accompanied by a parameter that is resolved during the attachment of the policy to an interface. An external rate-limit aggregation node can be defined by the 4-tuple (slot, direction, external parent group name, parameter value). The slot is the logical number of the line module location and the direction can be ingress or egress at the line module.

When you use hierarchical aggregation nodes, be aware of the following:

- VR/VRF—The hierarchical aggregate nodes based on external parent groups are not virtual router sensitive. The configuration allows interfaces from different virtual routers to have the same parameter name to value mapping, in which case both interfaces could share the same aggregate node created by an external parent group.

- **Direction of Traffic**—Hierarchical aggregate nodes are direction sensitive. The configuration does not allow input and output traffic at an interface to share the same rate-limit instance. Even when the input and output policy attachments refer to the same external parent group and parameter value, two separate aggregate nodes are created for each direction.
- **Line Module**—You should use hierarchical aggregate nodes. Rate limits cannot be shared across different line modules or service modules. Even when you configure the same parameter name to the same value for an external parent group, different rate-limit instances are instantiated if the interfaces are on different line modules.

RADIUS and Profile Configuration for Hierarchical Policies

You can use profiles to configure policy parameters. There is currently no RADIUS VSA support for policy parameters. Each reference to an external parent group and the chain of references from that group to other parent groups in a series requires one parent group resource for each reference and each attachment of the policy containing these references.

The rule that applies to external parent group resource count is: one resource per (interface, policy attachment type, policy name, external parent group name, parameter name) tuple; interface is the interface where the policy is attached and policy attachment type is the type of policy attachment.

A rate-limit instance for the external parent groups is created for each hierarchical aggregation node, which is a combination of (slot, direction, parent group name, parameter value) tuple; where slot is the slot number, direction is ingress or egress. A rate-limit resource will be consumed for each instance created.

If at least one policy attachment that uses an external parent group reference has statistics enabled, then statistics for the rate-limit configured within the external parent group is enabled. Each hierarchical aggregation node requires five statistics resources.

Applying a Profile to Interfaces with Service Manager

Applying a profile to the interface where the subscriber sends and receives traffic activates service for a subscriber. Similarly, to deactivate a service, you reapply the respective profile with a *negate* flag.

You can use a profile to apply the policy parameters configuration for an interface. When you apply a profile containing relevant policy parameter commands to an interface, the parameter configuration is uniquely maintained for each dynamic interface created using this profile. The policy parameters are not deactivated when the corresponding service containing them is deactivated and can only be modified or created by service activations.

If you write service manager macros, you should define the rate-limit hierarchy when you create the policies and profiles associated with the services to be deployed.

Hierarchical Policy Configuration Considerations

When you configure hierarchical policies for interface groups, be aware of the following considerations:

- **Loops**—The system performs basic checks to prevent formation of loops when external parent groups refer to other external parent groups. Also, you cannot chain together more than four rate-limits in a hierarchy.
- **Asynchronous Policy Parameter Configuration**—You can individually configure the policy parameter configuration in an interface and the policy attachments. If a policy parameter is not configured in the interface before a policy is attached, the value configured in Global Configuration mode for this parameter is used. You can later change the parameter value for the interface.
- **Asynchronous Parent Group Rate Limit Configuration**—You can configure an external parent group without a rate-limit-profile reference. In this case, the system does not invoke a rate-limit for the external parent group (even if other nodes point to it) and calls the next node in the hierarchy.
- **Parent Group Reference**—The configuration fails if you do not first create an external parent group before it is referenced elsewhere.

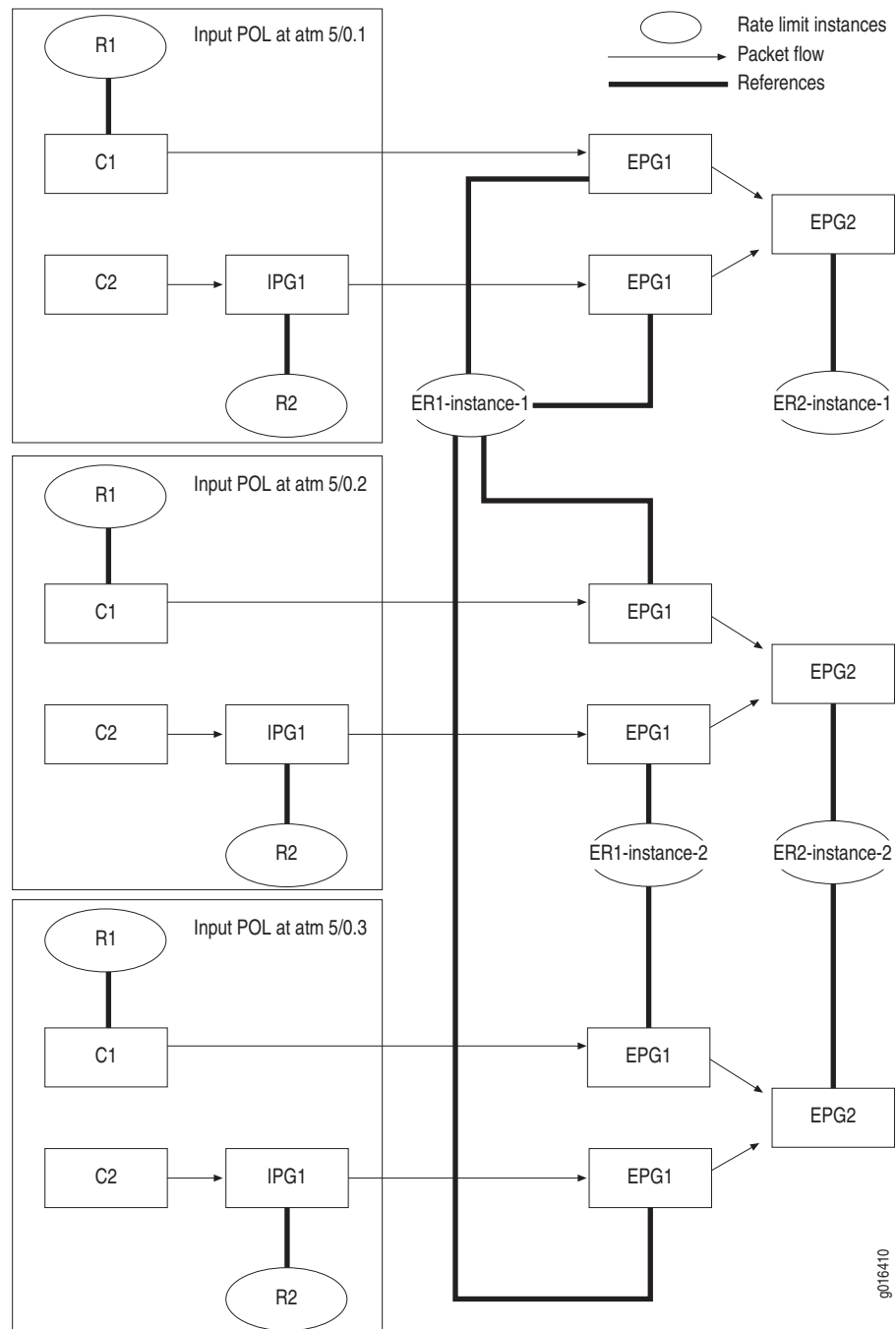
Example: Hierarchical Policy Quick Configuration

To configure hierarchical policies for interface groups, use the following steps:

1. In Global Configuration mode, create rate limit profiles of the type hierarchical.
2. In Global Configuration mode, create policy parameters of the type hierarchical.
3. In Global Configuration mode, create external parent groups.
4. In Global Configuration mode, create a policy list and use the external parent groups and policy parameters to create a hierarchy of rate limits.
5. In Interface Configuration mode, attach the policy list to the interface.
6. (Optional) In Interface Configuration mode, specify values for the hierarchical policy parameters used by the policy list.

Example: Configuring Hierarchical Policies

The configuration in Figure 8 requires four parent group resources for each atm5/0.1, atm5/0.2, and atm5/0.3 attachment. The rate-limit instance R1 is referenced by C1 and packet flows from C1 to EPG1 to EPG2.

Figure 8: Step-by-Step Configuration

This procedure uses the following designations:

- EPG1 and EPG2 are external parent groups.
- IP1 and IP2 are internal parent groups.
- ER1, ER2, R1, and R2 are rate-limit profiles.

- POL is the name of the IP policy.
 - C1 and C2 are classified flows.
 - A, B, and C are policy parameters.
1. Configure two external parent groups EPG1 and EPG2. Create policy-parameter C and two external parent groups: EPG1 and EPG2.

```
host1(config)#policy-parameter C hierarchical
host1(config-policy-parameter)#exit
```

```
host1(config)#parent-group EPG2
host1(config-parent-group)#rate-limit-profile ER2
host1(config-parent-group)#exit
```

```
host1(config)#parent-group EPG1
host1(config-parent-group)#next-parent EPG2 parameter C
host1(config-parent-group)#rate-limit-profile ER1
host1(config-parent-group)#exit
```

EPG1 contains a rate-limit profile ER1 and points to EPG2 as the next parent group in series. The EPG2 reference is associated with policy parameter C. When you later use the **policy-parameter** command in Interface Configuration mode, actual values are substituted for the names. EPG2 contains a reference to rate-limit-profile ER2.

2. Configure IP policy list POL.

```
host1(config)#ip policy-list POL
host1(config-policy-list)#classifier-group C1 external parent-group EPG1
parameter A
host1(config-policy-list-classifier-group)#rate-limit-profile R1
host1(config-policy-list-classifier-group)#exit
```

```
host1(config-policy-list)#classifier-group C2 parent-group IPG1
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
```

```
host1(config-policy-list)#parent-group IPG1 external parent-group EPG1
parameter B
host1(config-parent-group)#rate-limit-profile R2
host1(config-policy-list-parent-group)#exit
```

A classified flow C1 references EPG1 as the next parent group to call in the hierarchy. This is an external parent group that is associated with policy parameter A. The C2 classified flow points to internal parent group IPG1, which contains rate-limit-profile R2 and points to EPG1 as the next parent group to call in the hierarchy. The EPG1 reference is associated with policy parameter B. When you later use the **policy-parameter** command in Interface Configuration mode, the policy parameters are given numeric values.

3. Attach POL to atm5/0.1 as an input policy.

```
host1(config)#interface atm 5/0.1
host1(config-interface)#ip policy-parameter hierarchical A 1
host1(config-interface)#ip policy-parameter hierarchical B 1
host1(config-interface)#ip policy-parameter hierarchical C 1
host1(config-interface)#ip policy input POL statistics enabled
host1(config-interface)#exit
```

Policy list POL contains three parameter names that must be substituted with actual values. This attachment contains two internal rate-limit instances, one for R1 and one for R2. This attachment also contains one parent group instance for IPG1, one parent-group instance for (EPG1, parameter A) tuple, one for (EPG1, parameter B) tuple, and one for (EPG2, parameter C) tuple. Value number 1 is substituted for parameters A, B, and C when you use the **policy-parameter** command. Because of this policy attachment and the **policy-parameter** command, the following aggregation nodes are created: (slot 5, ingress, EPG1, 1), (slot 5, ingress, EPG2, 1). The system creates a rate-limit instance for each aggregation node: ER1-instance-1 and ER2-instance-1, respectively. ER1-instance-1 is referenced in parent-group instances (EPG1, parameter A) and (EPG1, parameter B). ER2-instance-1 is referenced in the parent group instance (EPG2, parameter C).

4. Attach POL to atm5/0.2 as input policy.

```
host1(config)#interface atm 5/0.2
host1(config-interface)#ip policy-parameter hierarchical A 1
host1(config-interface)#ip policy-parameter hierarchical B 2
host1(config-interface)#ip policy-parameter hierarchical C 2
host1(config-interface)#ip policy input POL statistics enabled
host1(config-interface)#exit
```

Policy list POL contains three parameter names that must be substituted with actual values. This attachment consumes two internal rate-limit instances: one for R1 and one for R2. This attachment also consumes one parent group instance for IPG1, one parent-group instance for (EPG1, parameter A) tuple, one for (EPG1, parameter B) tuple, and one for (EPG2, parameter C) tuple as in Step 3. When you use the **policy-parameter** command, parameter A is substituted with value 1 and parameters B and C are substituted with value 2. Because of this policy attachment and the **policy-parameter** commands, the following aggregation nodes are identified: (slot 5, ingress, EPG1, 1), (slot 5, ingress, EPG1, 2), (slot 5, ingress, EPG2, 2). The (slot 5, ingress, EPG1, 1) node was already created in Step 3 and was named ER1-instance-1. The other two aggregation nodes are now created and named ER1-instance-2 and ER2-instance-2, respectively. ER1-instance-1 is referenced by parent-group instance (EPG1, parameter A), ER1-instance-2 is referenced by parent group instance (EPG1, parameter B), and ER2-instance-2 is referenced by the parent group instance (EPG2, parameter C).

5. Attach POL to atm5/0.3 as input policy.

```
host1(config)#interface atm 5/0.3
host1(config-interface)#ip policy-parameter hierarchical A 2
host1(config-interface)#ip policy-parameter hierarchical B 1
host1(config-interface)#ip policy-parameter hierarchical C 2
host1(config-interface)#ip policy input POL statistics enabled
host1(config-interface)#exit
```

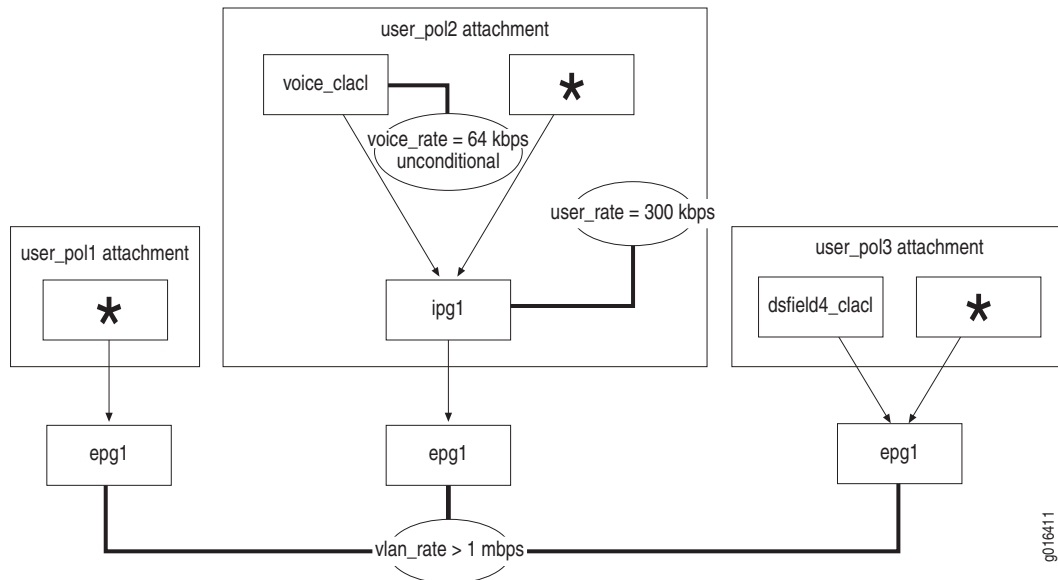
Policy list POL contains three parameter names that need to be substituted with actual values. This attachment consumes two internal rate-limit instances: one for R1 and one for R2. This attachment also consumes one parent group instance for IPG1, one parent-group instance for (EPG1, parameter A) tuple, one for (EPG1, parameter B) tuple, and one for (EPG2, parameter C) tuple. When you use the **policy-parameter** command, parameters A and C are substituted with value 2 and parameter B is substituted with value 1. Because of this policy attachment and use of the **policy-parameter** commands, the following aggregation nodes are identified; (slot 5, ingress, EPG1, 2), (slot 5, ingress, EPG1, 1), (slot 5, ingress, EPG2, 2). All three aggregation nodes were created in earlier steps and were named ER1-instance-2, ER1-instance-1, and ER2-instance-2, respectively. ER1-instance-2 is referenced by parent-group instances (EPG1, parameter A), ER1-instance-1 is referenced by parent group instance (EPG1, parameter B), and ER2-instance-2 is referenced by the parent group instance (EPG2, parameter C).

Example: VLAN Rate Limit Hierarchical Policy for Interface Groups Configuration

In this example, three users from a small business office are connected to an E-series router through the same VLAN interface. The contracted maximum for the business is 1 Mbps in the upstream direction. The downstream direction is served through QoS profiles and therefore is not shown here.

Figure 9 shows the following:

- User user_pol1 is attached to the first user's IP interface and does not have a rate limit.
- User user_pol2 is attached the second user's interface and has an individual rate limit of 300Kbps and preferred voice traffic at 64Kbps.
- User user_pol3 is attached to the third user's interface and has some traffic marked with a low delay (Dsfield = 4), but there are no rate limitations applied.
- Policer instance VLAN_RATE is shared across all three instances of EPG1 and limits the total upstream traffic from three users to 1 Mbps.

Figure 9: VLAN Rate-Limit Configuration

1. Create a rate limit to enforce the contracted maximum for the small business. Create an external parent group to hold this rate limit.

```
host1(config)#rate-limit-profile VLAN_RATE two-rate hierarchical
host1(config-rate-limit-profile)#committed-rate 1000000
host1(config-rate-limit-profile)#committed-action transmit final
host1(config-rate-limit-profile)#exit
```

```
host1(config)#parent-group EPG1
host1(config-parent-group)#rate-limit-profile VLAN_RATE
host1(config-parent-group)#exit
```

Verify the parent group configuration.

```
host1#show parent-group EPG1
```

Parent Group Table

```
Parent Group EPG1
Reference count: 0
Rate limit profile: VLAN_RATE
```

2. Create a policy list to attach to user 1.

```
host1(config)#policy-parameter A hierarchical
host1(config-policy-parameter)#exit
```

```
host1(config)#ip policy-list USER_POL1
host1(config-policy-list)#classifier-group * external parent-group EPG1
parameter A
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit
```

Verify the policy list configuration.

```
host1#show policy-list USER_POL1
```

```

Policy Table
-----
IP Policy USER_POL1
  Administrative state: enable
  Reference count:      0
  Classifier control list: *, precedence 100, external parent-group EPG1
  parameter A
  forward

```

3. Create a policy list to attach to user 2. Also, create a rate limit to police voice traffic and another rate limit to police all traffic for user 2. Because voice traffic is preferred, it borrows the tokens unconditionally from all aggregate policers in the hierarchy.

```

host1(config)#rate-limit-profile VOICE_RATE two-rate hierarchical
host1(config-rate-limit-profile)#committed-rate 64000
host1(config-rate-limit-profile)#committed-action transmit unconditional
host1(config-rate-limit-profile)#exit

```

```

host1(config)#rate-limit-profile USER_RATE two-rate hierarchical
host1(config-rate-limit-profile)#committed-rate 300000
host1(config-rate-limit-profile)#committed-action transmit conditional
host1(config-rate-limit-profile)#exit

```

```
host1(config)#ip classifier-list VOICE_CLACL udp any any eq 10000
```

```

host1(config)#ip policy-list USER_POL2
host1(config-policy-list)#classifier-group VOICE_CLACL parent-group IPG1
host1(config-policy-list-classifier-group)#rate-limit-profile VOICE_RATE
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group * parent-group IPG1
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#parent-group IPG1 external parent-group EPG1
parameter A
host1(config-policy-list-parent-group)#rate-limit-profile USER_RATE
host1(config-policy-list-parent-group)#exit
host1(config-policy-list)#exit

```

Verify the policy list configuration.

```
host1#show policy-list USER_POL1
```

```

Policy Table
-----
IP Policy USER_POL2
  Administrative state: enable
  Reference count:      0
  Classifier control list: VOICE_CLACL, precedence 100, parent-group IPG1
    rate-limit-profile VOICE_RATE
  Classifier control list: *, precedence 100, parent-group IPG1
    forward
  Parent group: IPG1, external parent-group EPG1 parameter A
    rate-limit-profile USER_RATE

```

4. Create a policy list to attach to user 3 and mark Dsfield = 4 traffic with a special traffic class.

```

host1(config)#ip classifier-list DSFIELD4_CLACL ip any any dsfield 4
host1(config)#ip policy-list USER_POL3
host1(config-policy-list)#classifier-group DSFIELD4_CLACL external parent-group
EPG1 parameter A
host1(config-policy-list-classifier-group)#traffic-class LOW_DROP
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group * external parent-group EPG1
parameter A
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit

```

The policies created earlier are attached statically to the user's corresponding entry interface in the E-series router. In this case, fast3/0.1 connects to user 1, fast3/0.2 connects to user 2, and fast3/0.3 connects to user 3.

5. Create the major interface.

```

host1(config)#interface fastEthernet 3/0
host1(config-interface)#encapsulation vlan
host1(config-interface)#exit

```

6. Create an interface for user 1, attach USER_POL1, and map parameter A to the VLAN interface stacked below the shared IP interface.

```

host1(config)#interface fastEthernet 3/0.1
host1(config-interface)#vlan id 1
host1(config-interface)#exit

host1(config)#interface ip 3/0.1.1
host1(config-interface)#ip policy-parameter hierarchical A vlan
host1(config-interface)#ip policy input USER_POL1 statistics enabled
host1(config-interface)#exit

```

7. Create the interface for user 2, attach USER_POL2, and map parameter A to the VLAN interface.

```

host1(config)#interface ip 3/0.1.2
host1(config-interface)#ip policy-parameter hierarchical A vlan
host1(config-interface)#ip policy input USER_POL2 statistics enabled
host1(config-interface)#exit

```

8. Create the interface for user 3, attach USER_POL3, and map parameter A to the VLAN interface.

```

host1(config)#interface ip 3/0.1.3
host1(config-interface)#ip policy-parameter hierarchical A vlan
host1(config-interface)#ip policy input USER_POL3 statistics enabled
host1(config-interface)#exit

```

9. For dynamic users, under each user's record in RADIUS, you can specify the ingress policy name. However, you can only specify the policy parameter through the profile.

```
host1(config)#profile PPPoE_PROF1
host1(config-profile)#ip policy-parameter hierarchical A vlan
host1(config-profile)#exit
```

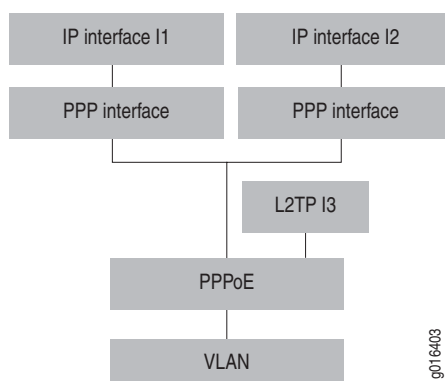
```
host1(config)#interface fastEthernet 3/0.1
host1(config-interface)#vlan id 1
host1(config-interface)#encapsulation pppoe
host1(config-interface)#profile PPPoE_PROF1
host1(config-interface)#pppoe auto-configure
host1(config-interface)#exit
```

Example: Wholesale L2TP Model Hierarchical Policy Configuration

In this example:

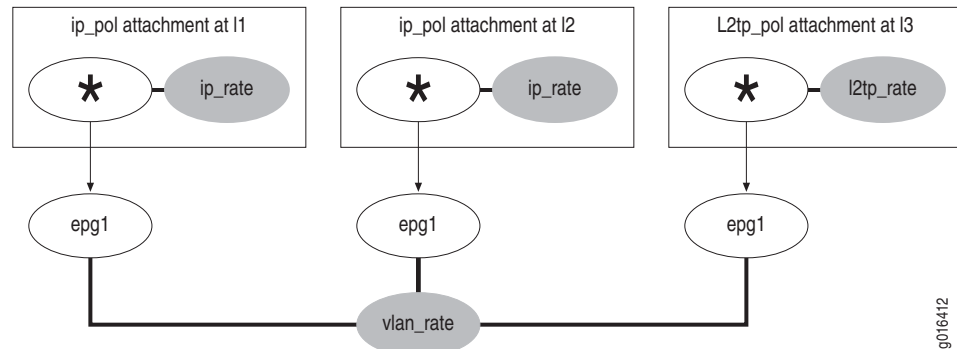
- There are two terminated subscribers and their corresponding IP interfaces are I1 & I2 in the E-series router.
- There is a single tunneled subscriber whose interface is I3.
- Interfaces I1 and I2 have dedicated 1 Mbps bandwidth each and interface I3 has dedicated 10 Mbps bandwidth. However, if interface I3 is not forwarding any traffic, then the allocated 10 Mbps can be shared by interfaces I1 and I2. Therefore, interfaces I1 and I2 can individually go up to a maximum of 11 Mbps if only one is actively sending traffic. If both interfaces are actively sending traffic, they can both get a maximum of 6 Mbps. However, any time interface I3 is actively sending traffic, it can forward up to the contracted 10 Mbps and interfaces I1 and I2 fall back to 1 Mbps.

Figure 10: Interface Stack for Wholesale L2TP Mode



To use this example, you must configure the following:

- At interfaces I1 and I2:
 - IP_RATE, Committed Rate: 1 Mbps
 - Peak Rate: 11 Mbps
 - Committed Action: transmit unconditional
 - Conformed Action: transmit conditional
 - Exceeded Action: drop
- At I3—L2TP_RATE:
 - Committed Rate: 10 Mbps
 - Peak Rate: 0 Mbps
 - Committed Action: transmit unconditional
 - Conformed Action: drop
 - Exceeded Action: drop
- Policers at I1, I2, and I3 feed into a single policer that has the following configuration:
 - VLAN_RATE, Committed Rate: 12 Mbps
 - Peak Rate: 0 Mbps
 - Committed Action: transmit final
 - Conformed Action: drop
 - Exceeded Action: drop
- IP policy USER_POL1 is attached as input to I1, IP policy USER_POL2 is attached as input to I2, and L2TP policy USER_POL3 is attached as input to I3.
- Policer instance VLAN_RATE is shared across all three instances of EPG1.

Figure 11: Wholesale L2TP Configuration

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1. Create a rate-limit that can be shared across all forwarding interfaces. Create an external parent group to hold this rate limit.

```
host1(config)#rate-limit-profile VLAN_RATE two-rate hierarchical
host1(config-rate-limit-profile)#committed-rate 12000000
host1(config-rate-limit-profile)#committed-action transmit final
host1(config-rate-limit-profile)#exit
```

```
host1(config)#parent-group EPG1
host1(config-parent-group)#rate-limit-profile VLAN_RATE
host1(config-parent-group)#exit
```

2. Create a policy list to attach to users 1 and 2.

```
host1(config)#rate-limit-profile IP_RATE two-rate hierarchical
host1(config-rate-limit-profile)#committed-rate 1000000
host1(config-rate-limit-profile)#committed-action transmit unconditional
host1(config-rate-limit-profile)#peak-rate 11000000
host1(config-rate-limit-profile)#conformed-action transmit conditional
host1(config-rate-limit-profile)#exit
```

```
host1(config)#policy-parameter A hierarchical
host1(config-policy-parameter)#exit
host1(config)#ip policy-list IP_POL
host1(config-policy-list)#classifier-group * external parent-group EPG1
parameter A
host1(config-policy-list-classifier-group)#rate-limit-profile IP_RATE
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit
```

3. Create a policy list to attach to user 3.

```
host1(config)#rate-limit-profile L2TP_RATE two-rate hierarchical
host1(config-rate-limit-profile)#committed-rate 10000000
host1(config-rate-limit-profile)#committed-action transmit unconditional
host1(config-rate-limit-profile)#exit
```



```

host1(config)#l2tp policy-list L2TP_POL
host1(config-policy-list)#classifier-group * external parent-group EPG1
parameter A
host1(config-policy-list-classifier-group)#rate-limit-profile L2TP_RATE
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit

```

4. In both terminated users' record in RADIUS, you must specify the ingress policy name IP_POL. You must specify the ingress policy name L2TP_POL in the tunneled user's record in RADIUS. However, be sure to specify the policy parameter through a profile.

```

host1(config)#profile PPPOE_PROF1
host1(config-profile)#ip policy-parameter hierarchical A 1
host1(config-profile)#l2tp policy-parameter hierarchical A 1
host1(config-profile)#exit

```

```

host1(config)#interface fastEthernet 3/0.1
host1(config-interface)#vlan id 1
host1(config-interface)#encapsulation pppoe
host1(config-interface)#profile PPPOE_PROF1
host1(config-interface)#pppoe auto-configure
host1(config-interface)#exit

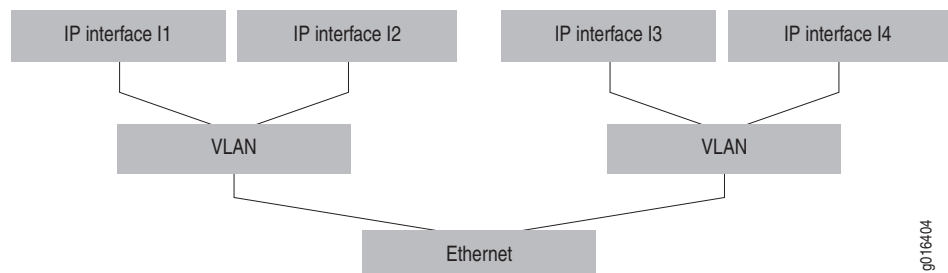
```

Example: Aggregate Rate Limit for All Nonvoice Traffic Hierarchical Policy Configuration

In this example:

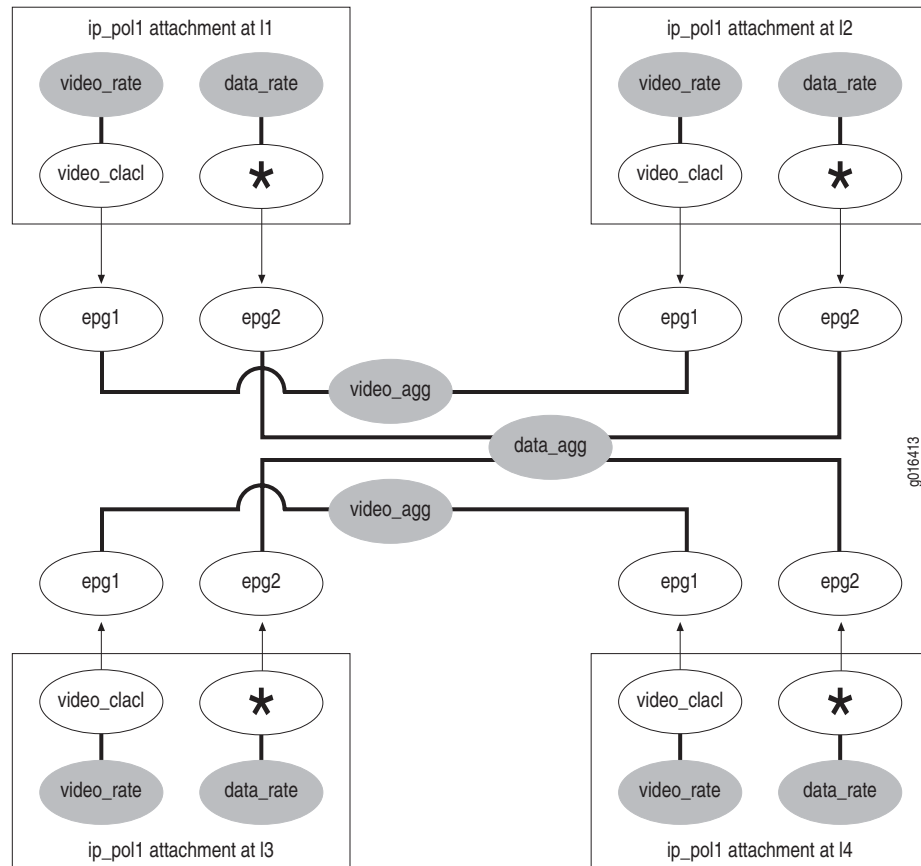
- There are four IP sessions and their corresponding interfaces are I1, I2, I3, and I4.
- Each interface corresponds to a dynamic user.
- All users can send a maximum of 1 Mbps video traffic each, but the total bandwidth for all video traffic combined is 1.5 Mbps for a specific VLAN.
- Similarly, all users can send a maximum of 5 Mbps data traffic, but the sum of all data traffic on an Ethernet port is 10 Mbps. Interfaces I1-I4 are interfaces where you can attach policies.

Figure 12: Interface Stack for Aggregate Rate Limit



This example uses the following:

- At I1, I2, I3, I4:
 - Classified Video Flow. VIDEO_RATE, Committed Rate: 1 Mbps
 - Peak Rate: 0 Mbps
 - Committed Action: transmit conditional
 - Conformed Action: drop
 - Exceeded Action: drop
- At I1, I2, I3, I4:
 - Classified Data Flow. DATA_RATE, Committed Rate: 5 Mbps
 - Peak Rate: 0 Mbps
 - Committed Action: transmit conditional
 - Conformed Action: drop
 - Exceeded Action: drop
- All classified video flow policers over each VLAN interface feed into a single policer with the following configuration:
 - VIDEO_AGG, Committed Rate: 1.5 Mbps
 - Peak Rate: 0 Mbps
 - Committed Action: transmit final
 - Conformed Action: drop
 - Exceeded Action: drop
- All classified data flow policers over each Ethernet port feed into a single policer with the following configuration:
 - DATA_AGG, Committed Rate: 10 Mbps
 - Peak Rate: 0 Mbps
 - Committed Action: transmit final
 - Conformed Action: drop
 - Exceeded Action: drop
- Policy IP_POL1 is attached to I1, I2, I3, and I4

Figure 13: Aggregate Rate Limit for Nonvoice Traffic Configuration

1. Create a rate limit that can be shared across all video streams. Create an external parent group to hold this rate limit.

```
host1(config)#rate-limit-profile VIDEO_AGG two-rate hierarchical
host1(config-rate-limit-profile)#committed-rate 1500000
host1(config-rate-limit-profile)#committed-action transmit final
host1(config-rate-limit-profile)#exit
```

```
host1(config)#parent-group EPG1
host1(config-parent-group)#rate-limit-profile VIDEO_AGG
host1(config-parent-group)#exit
```

2. Create a policy list to attach to all IP sessions.

```
host1(config)#rate-limit-profile VIDEO_RATE two-rate hierarchical
host1(config-rate-limit-profile)#committed-rate 1000000
host1(config-rate-limit-profile)#committed-action transmit conditional
host1(config-rate-limit-profile)#exit
```

```
host1(config)#rate-limit-profile DATA_RATE two-rate hierarchical
host1(config-rate-limit-profile)#committed-rate 5000000
host1(config-rate-limit-profile)#committed-action transmit conditional
host1(config-rate-limit-profile)#exit
```

```

host1(config)#policy-parameter A hierarchical
host1(config-policy-parameter)#exit
host1(config)#policy-parameter B hierarchical
host1(config-policy-parameter)#exit

host1(config)#ip policy-list IP_POL1
host1(config-policy-list)#classifier-group VIDEO_CLACL external parent-group
EPG1 parameter A
host1(config-policy-list-classifier-group)#rate-limit-profile VIDEO_RATE
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group * external parent-group EPG2
parameter B
host1(config-policy-list-classifier-group)#rate-limit-profile DATA_RATE
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit

```

3. In all users' records in RADIUS, specify the ingress policy name IP_POL1. However, be sure to specify the policy parameter through the profile.

```

host1(config)#profile PPPOE_PROF1
host1(config-profile)#ip policy-parameter hierarchical A vlan
host1(config-profile)#ip policy-parameter hierarchical B ethernet
host1(config-profile)#exit

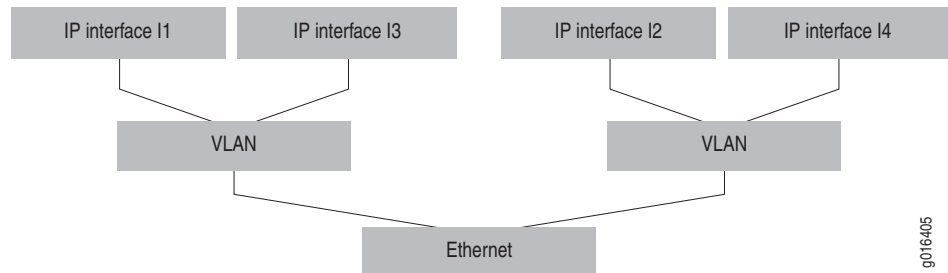
host1(config)#interface fastEthernet 3/0.1
host1(config-interface)#vlan id 1
host1(config-interface)#encapsulation pppoe
host1(config-interface)#profile PPPOE_PROF1
host1(config-interface)#pppoe auto-configure
host1(config-interface)#exit

```

Example: Arbitrary Interface Groups Hierarchical Policy Configuration

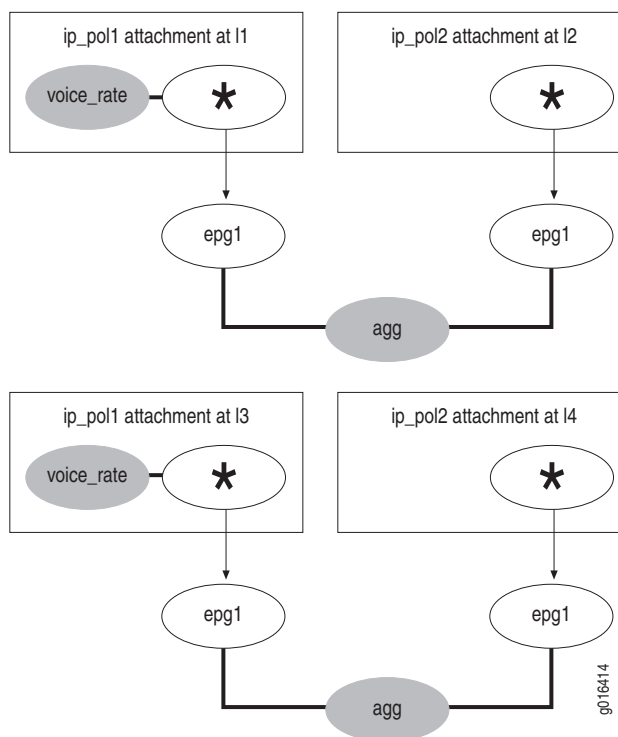
In this example, there are four terminated sessions and their corresponding IP interfaces are I1, I2, I3, and I4. Figure 14 on page 135 shows the following:

- Sessions I1 and I2 are for the same subscriber: I1 carries only voice traffic and I2 carries all other traffic for this subscriber
- Sessions I3 and I4 are for another subscriber.
- Voice traffic has a contracted minimum of 64 Kbps, but the combined voice and other traffic for each subscriber has a contracted maximum of 1 Mbps.
- Interfaces I1-I4 are interfaces where you can attach policies.

Figure 14: Interface Stack for Arbitrary Interface Groups

This example uses the following:

- At I1 and I3:
 - VOICE_RATE, Committed Rate: 64 Kbps
 - Peak Rate: 0 Mbps
 - Committed Action: transmit unconditional
 - Conformed Action: drop
 - Exceeded Action: drop
- At I2 and I4:
 - No policer configured
 - I1 and I2 feed into a single policer with the following configuration: AGG, Committed Rate: 1 Mbps, Peak Rate: 0 Mbps, Committed Action: transmit, Conformed Action: drop, Exceeded Action: drop

Figure 15: Arbitrary Interface Groups Configuration

1. Create an aggregate rate limit that can be shared across multiple interfaces. Create an external parent group to hold this rate limit.

```
host1(config)#rate-limit-profile AGG two-rate hierarchical
host1(config-rate-limit-profile)#committed-rate 1000000
host1(config-rate-limit-profile)#committed-action transmit final
host1(config-rate-limit-profile)#exit
```

```
host1(config)#parent-group EPG1
host1(config-parent-group)#rate-limit-profile AGG
host1(config-parent-group)#exit
```

2. Create a policy list to be attached to all voice sessions.

```
host1(config)#rate-limit-profile VOICE_RATE two-rate hierarchical
host1(config-rate-limit-profile)#committed-rate 64000
host1(config-rate-limit-profile)#committed-action transmit unconditional
host1(config-rate-limit-profile)#exit
```

```
host1(config)#policy-parameter A hierarchical
host1(config-policy-parameter)#exit
```

```
host1(config)#ip policy-list IP_POL1
host1(config-policy-list)#classifier-group * external parent-group EPG1
parameter A
host1(config-policy-list-classifier-group)#rate-limit-profile VOICE_RATE
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit
```

3. Create a policy list to attach to all other sessions.

```
host1(config)#ip policy-list IP_POL2
host1(config-policy-list)#classifier-group * external parent-group EPG1
parameter A
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit
```

4. Attach IP_POL1 to the voice session of first user and attach IP_POL2 to the other session for the same user. Specify the same ID for parameter A.

```
host1(config)#interface fastEthernet 3/0.1
host1(config-interface)#vlan id 1
host1(config-interface)#exit
```

```
host1(config)#interface ip 3/0.1.1
host1(config-interface)#ip policy-parameter hierarchical A 1
host1(config-interface)#ip policy input IP_POL1 statistics enable
host1(config-interface)#exit
```

```
host1(config)#interface fastEthernet 3/0.2
host1(config-interface)#vlan id 2
host1(config-interface)#exit
```

```
host1(config)#interface ip 3/0.2.1
host1(config-interface)#ip policy-parameter hierarchical A 1
host1(config-interface)#ip policy input IP_POL2 statistics enable
host1(config-interface)#exit
```

5. Attach IP_POL1 to the voice session of the second user and attach IP_POL2 to the other session for the same user. Specify a different ID for parameter A.

```
host1(config)#interface ip 3/0.1.2
host1(config-interface)#ip policy-parameter hierarchical A 2
host1(config-interface)#ip policy input IP_POL1 statistics enable
host1(config-interface)#exit
```

```
host1(config)#interface ip 3/0.2.2
host1(config-interface)#ip policy-parameter hierarchical A 2
host1(config-interface)#ip policy input IP_POL2 statistics enable
host1(config-interface)#exit
```

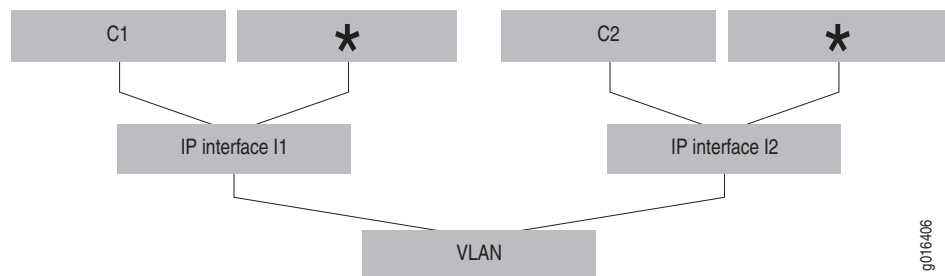
Example: Service and User Rate-Limit Hierarchy Overlap Hierarchical Policy Configuration

In the service and user rate-limit hierarchy overlap configuration example:

- The service provider has to enforce a bandwidth limit on a video service over a VLAN and wants to limit the maximum bandwidth of each user's total traffic.
- There are two terminated sessions and their corresponding IP interfaces are I1 and I2.

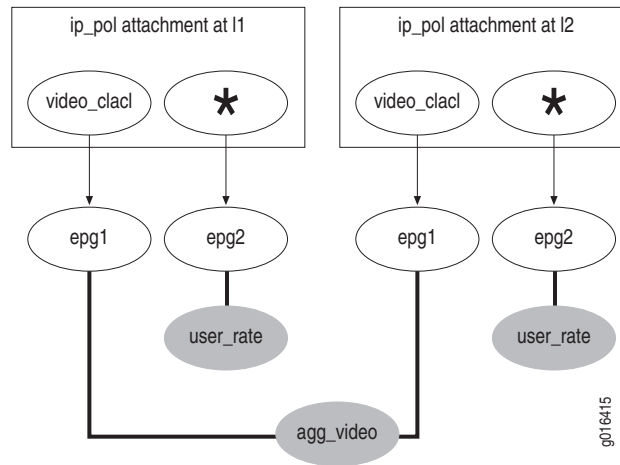
- Each session contains a video flow classified by C1 and all other traffic is classified by an asterisk (*).
- All video flows over the VLAN are rate-limited to a common rate of 1 Mbps.
- Each session is individually rate-limited by 2 Mbps.
- You can attach policies at interface I1-I2.

Figure 16: Interface Stack for Service and User Rate-Limit Hierarchy Overlap



This example uses the following:

- At I1 and I2:
 - USER_RATE, Committed Rate: 2 Mbps
 - Peak Rate: 0 Mbps
 - Committed Action: transmit final
 - Conformed Action: drop
 - Exceeded Action: drop
- Both C1 and C2 feed into a single policer with the following configuration:
 - AGG_VIDEO, Committed Rate: 1 Mbps
 - Peak Rate: 0 Mbps
 - Committed Action: transmit conditional
 - Conformed Action: drop
 - Exceeded Action: drop

Figure 17: Service and User Rate-Limit Hierarchy Overlap Configuration

1. Create an aggregate rate limit that can be applied to each IP session. Create an external parent group to hold this rate limit.

```
host1(config)#rate-limit-profile USER_RATE two-rate hierarchical
host1(config-rate-limit-profile)#committed-rate 2000000
host1(config-rate-limit-profile)#committed-action transmit final
host1(config-rate-limit-profile)#exit
```

```
host1(config)#parent-group EPG2
host1(config-parent-group)#rate-limit-profile USER_RATE
host1(config-parent-group)#exit
```

2. Create an aggregate rate limit that can be shared across multiple video streams. Create an external parent group to hold this rate limit.

```
host1(config)#rate-limit-profile AGG_VIDEO two-rate hierarchical
host1(config-rate-limit-profile)#committed-rate 1000000
host1(config-rate-limit-profile)#committed-action transmit conditional
host1(config-rate-limit-profile)#exit
```

```
host1(config)#policy-parameter B hierarchical
host1(config-policy-parameter)#exit
```

```
host1(config)#parent-group EPG1
host1(config-parent-group)#next-parent EPG2 parameter B
host1(config-parent-group)#rate-limit-profile AGG_VIDEO
host1(config-parent-group)#exit
```

3. Create a policy list to be attached to each IP session.

```
host1(config)#ip classifier-list VIDEO_CLACL udp any any eq 4000
```

```
host1(config)#policy-parameter A hierarchical
host1(config-policy-parameter)#exit
```

```
host1(config)#ip policy-list IP_POL
host1(config-policy-list)#classifier-group VIDEO_CLACL external parent-group
EPG1 parameter A
```

```

host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#classifier-group * external parent-group EPG2
parameter B
host1(config-policy-list-classifier-group)#forward
host1(config-policy-list-classifier-group)#exit
host1(config-policy-list)#exit

```

4. Attach IP_POL to each IP session. Specify the same ID for parameter A, but a different ID for parameter B.

```

host1(config)#interface fastEthernet 3/0.1
host1(config-interface)#vlan id 1
host1(config-interface)#exit

```

```

host1(config)#interface ip 3/0.1.1
host1(config-interface)#ip policy-parameter hierarchical A vlan
host1(config-interface)#ip policy-parameter hierarchical B forwarding
host1(config-interface)#ip policy input IP_POL statistics enable
host1(config-interface)#exit

```

```

host1(config)#interface ip 3/0.1.2
host1(config-interface)#ip policy-parameter hierarchical A vlan
host1(config-interface)#ip policy-parameter hierarchical B forwarding
host1(config-interface)#ip policy input IP_POL statistics enable
host1(config-interface)#exit

```