



Frame Relay PVC Bundles with QoS Support for IP and MPLS

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Frame Relay permanent virtual circuit (PVC) bundle functionality allows you to associate a group of Frame Relay PVCs with a single next-hop address. When Frame Relay PVC bundles are used with IP, packets are mapped to specific PVCs in the bundle on the basis of the precedence value or differentiated services code point (DSCP) settings in the type of service (ToS) field of the IP header. Each packet is treated differently according to the QoS configured for each PVC.

MPLS QoS support for Frame Relay PVC bundles extends Frame Relay PVC bundle functionality to support the mapping of Multiprotocol Label Switching (MPLS) packets to specific PVCs in the bundle. MPLS packets are mapped to PVCs according to the settings of the experimental (EXP) bits in the MPLS packet header.

- [Finding Feature Information, page 1](#)
- [Prerequisites for Frame Relay PVC Bundles with QoS Support for IP and MPLS, page 2](#)
- [Restrictions for Frame Relay PVC Bundles with QoS Support for IP and MPLS, page 2](#)
- [Information About Frame Relay PVC Bundles with QoS Support for IP and MPLS, page 2](#)
- [How to Configure Frame Relay PVC Bundles with QoS Support for IP and MPLS, page 5](#)
- [Configuration Examples for Frame Relay PVC Bundles with QoS Support for IP and MPLS, page 17](#)
- [Additional References, page 23](#)
- [Feature Information for Frame Relay PVC Bundles with QoS Support for IP and MPLS, page 24](#)
- [Glossary, page 25](#)

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.



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Prerequisites for Frame Relay PVC Bundles with QoS Support for IP and MPLS

To implement Frame Relay PVC bundles between two routers, you must enable IP Cisco Express Forwarding switching on the routers.

To configure MPLS EXP levels on bundle member PVCs, you must have tag-switching enabled on the interface.

It is recommended (but not required) that you implement PVC Interface Priority Queueing (PIPQ) in conjunction with Frame Relay PVC bundles. This will ensure that if the interface becomes congested, higher-priority traffic can exit the interface ahead of lower-priority traffic.

Restrictions for Frame Relay PVC Bundles with QoS Support for IP and MPLS

- A PVC can be a part of one and only one PVC bundle.
- A PVC bundle may contain no more than eight PVCs.
- A PVC that is a bundle member cannot be used in any other capacity. For example a PVC bundle member cannot be configured in a map statement.
- A PVC bundle cannot perform precedence and DSCP matching at the same time. If the wrong matching scheme is configured, unpredictable behavior will result.
- A PVC bundle will not come up unless all the precedence, DSCP, or EXP levels are configured in the bundle.
- Voice over Frame Relay (VoFR) is not supported on PVC-bundle members.
- Fast switching over Frame Relay PVC bundles is not supported.

Information About Frame Relay PVC Bundles with QoS Support for IP and MPLS

- [Benefits of Frame Relay PVC Bundles with QoS Support for IP and MPLS, page 2](#)
- [Frame Relay PVC Bundle Support, page 3](#)
- [Frame Relay PVC Bundle Management, page 4](#)

Benefits of Frame Relay PVC Bundles with QoS Support for IP and MPLS

- IP or MPLS packets carrying different types of traffic can be transported on different PVCs within the same PVC bundle.
- Precedence-based PVC bundles can be converted to EXP-based PVC bundles by enabling tag-switching. EXP-based PVC bundles can be converted to precedence-based PVC bundles by disabling tag-switching.

- This feature provides flexible PVC management within a PVC bundle by allowing traffic assigned to a failed PVC to be redirected to an alternate PVC within the bundle. This feature also allows you to configure the bundle to go down when certain PVCs go down.

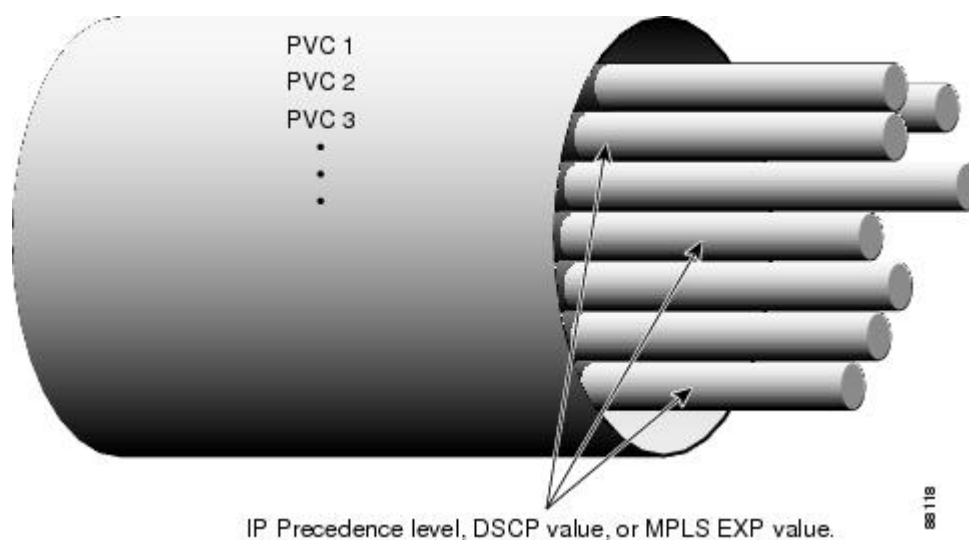
Frame Relay PVC Bundle Support

The use of Frame Relay PVC bundles allows you to configure multiple PVCs with different QoS characteristics between any pair of Frame Relay-connected routers. As shown in the figure below, a PVC bundle may contain up to eight PVCs. The individual PVCs within a bundle are called *bundle members*.

To determine which PVC in a bundle will be used to forward a specific type of traffic, the router maps the IP precedence level or DSCP value in an IPv4 packet header to a PVC configured with the same value. In the case of MPLS, packets are mapped to specific PVCs in a bundle based on the settings of the EXP bits in the MPLS packet headers.

Once you define a Frame Relay bundle and add PVCs to it, you can configure attributes and characteristics to discrete PVC bundle members, or you can apply them collectively at the bundle level. Frame Relay traffic shaping may be applied to every PVC within a bundle. As with individual PVCs, you can enable rate adaptation to occur in response to incoming backward explicit congestion notifications (BECN) from the network.

Figure 1 Frame Relay PVC bundle



You can create differentiated service using PVC bundles by distributing IP precedence levels or DSCP values over the various bundle members. You can map either a single precedence level or a range of precedence levels to each PVC in the bundle. Thus, either you can limit an individual PVC to carry only packets marked with a specific precedence level or you can enable a PVC to carry packets marked with different precedence levels.

- [Service Levels and PVC Selection Criteria, page 3](#)

Service Levels and PVC Selection Criteria

The DSCP and Precedence bits classify IP packet service levels. The Precedence field consists of the first three bits of the ToS octet in the IPv4 header. These bits define eight precedence levels. When DSCP

mapping is used, the DSCP octet replaces the ToS octet in the IPv4 header. Currently the first six bits are used, defining 64 service levels.

Using precedence-based or DSCP-based mapping, each IPv4 packet is mapped to a specific PVC in the bundle, according to the value of the ToS or DSCP octet in the IP header. There is no special treatment for broadcast or multicast or IP routing packets; the only differentiation in treatment is a result of the ToS or DSCP octet settings.

The MPLS EXP bits make up a three-bit experimental field in the MPLS packet header. They are a bit-by-bit copy of the IP Precedence bits and provide the same eight QoS levels. Under MPLS EXP-based mapping, each MPLS packet is mapped to a specific PVC in the bundle, according the setting of the EXP bits.

Frame Relay PVC Bundle Management

In addition to mapping specific traffic types to specific PVCs according to QoS parameters designated by the ToS or DSCP values in the IPv4 headers or EXP values in the MPLS headers, PVC bundle management takes care of handling non-IP traffic and determining what happens if a PVC goes down.

By default, Inverse Address Resolution Protocol (ARP) traffic and other critical non-IP traffic is carried by the PVC configured for carrying IP Precedence or EXP level 6 or DSCP level 63. You can select a PVC with a different QoS to carry Inverse ARP traffic if required. Noncritical non-IP traffic is carried by the PVC that configured for carrying IP precedence, EXP, or DSCP level 0.

It is important during configuration to account for every precedence, EXP, or DSCP level in the configuration of the PVC bundle members. If all the packet service levels are not accounted for, the PVC bundle will never come up.

Once a PVC bundle is up, if an individual bundle member goes down, an attempt is made to identify an alternate PVC to handle the packet service level or levels that were carried by the downed PVC. If no alternate PVC is found, the entire PVC bundle is brought down.

- [Traffic Bumping, page 4](#)
- [PVC-Bundle Protection Rules, page 4](#)
- [MPLS EXP-based Mapping, page 5](#)

Traffic Bumping

You can configure each PVC bundle member to bump traffic to another PVC in the bundle in the event that the bundle member goes down. You can specify whether the bumping will be implicit or explicit bumping. You can also specify that a particular PVC will never accept bumped traffic from another PVC. The default conditions are to perform implicit traffic bumping and to accept bumped traffic.

Implicit bumping diverts the traffic from a failed PVC to the PVC having the next-lower service level. Explicit bumping forces the traffic to a specific PVC rather than allowing it to find a PVC carrying traffic of the next-lower service level. For example, PVC *x*, responsible for carrying precedence level 3 traffic, can be configured to bump its traffic to PVC *y*, responsible for carrying precedence level 6 traffic-- provided that PVC *y* is configured to accept bumped traffic. If PVC *x* goes down, PVC *y* takes over. If PVC *y* is already down or goes down later, the alternate PVC selected will depend on the bumping rule for PVC *y*. If no alternate PVC can be found for bumped traffic, the entire PVC bundle goes down.

PVC-Bundle Protection Rules

Traffic bumping provides a way to keep a PVC bundle up and traffic flowing even though some individual PVCs may be down. Protection rules provide a way to force the PVC bundle down even though some

individual PVCs are up and might be able to handle all the traffic, though perhaps not in a satisfactory manner.

You can configure a PVC bundle member as an individually protected PVC or as part of a PVC bundle protected group. Only one protected group may exist within a PVC bundle; however, many individually protected PVCs may exist. The protection rules add flexibility for controlling the PVC bundle state.

When any one individually protected PVC goes down, the entire bundle goes down. If all the PVCs in a protected group go down, the entire bundle goes down.

If no protection rule is specified, the PVC bundle goes down only when all the PVCs go down. However, protection is overridden if a PVC that has no place to bump its traffic goes down. In this case, the entire bundle will go down despite any protection rules that have been set up.

MPLS EXP-based Mapping

To enable MPLS EXP-based mapping, tag-switching must be enabled on the interface or subinterface by using the **tag-switching ip** command. When tag-switching is enabled, MPLS and IP packets can flow across the interface and PVC bundles that are configured for IP Precedence mapping are converted to MPLS EXP mapping. The PVC bundle functionality remains the same with respect to priority levels, bumping, and so on, but the **match precedence** command is replaced by **match exp**, and each **precedence** command is replaced by the **exp** command. The effect is that a bundle member PVC previously configured to carry precedence level 1 IP traffic now carries EXP level 1 MPLS traffic.

PVC bundles configured for DSCP mapping go down when tag-switching is enabled. The DSCP configuration for each bundle member PVC is reset, resulting in the PVCs being unmapped and Inverse ARP, bumping, and protection settings being unconfigured. The **match dscp** command is replaced by **match exp** command.

When tag-switching is disabled, the **match precedence** and **match dscp** commands are restored and the **exp** commands are replaced by **precedence** commands.

When tag-switching is enabled or disabled, PVC bundles configured for IP precedence mapping or MPLS EXP mapping will stay up and traffic will transmit over the appropriate bundle member PVCs.

How to Configure Frame Relay PVC Bundles with QoS Support for IP and MPLS

- [Configuring Frame Relay PVC Bundles with IP QoS Support, page 5](#)
- [Configuring Frame Relay PVC Bundles with MPLS QoS Support, page 10](#)
- [Verifying Frame Relay PVC Bundles Configuration, page 15](#)
- [Monitoring and Maintaining Frame Relay PVC Bundles, page 16](#)

Configuring Frame Relay PVC Bundles with IP QoS Support

To configure Frame Relay PVC bundles for handling IP packets, perform the following steps:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip routing**
4. **ip cef**
5. Do one of the following:
 - **interface** *type number*
 -
 -
 - **interface** *type number . subinterface-number*
 - **multipoint** | **point-to-point**
6. **encapsulation frame-relay** [**cisco** | **ietf**]
7. **ip address** *ip-address mask* [**secondary**]
8. **frame-relay map** *protocol protocol-address* { *dlci* | **vc-bundle** *vc-bundle-name* } [**broadcast**] [**ietf** | **cisco**]
9. **frame-relay vc-bundle** *vc-bundle-name*
10. **encapsulation** [**cisco** | **ietf**]
11. **match** { **dscp** *dscp-value* | **precedence** *precedence-value* }
12. **pvc** *dlci* [*vc-name*]
13. **class** *name*
14. Do one of the following:
 - **precedence** { *level* | **other** }
 -
 -
 - **dscp** { *level* | **other** }
15. **bump** { **explicit** *level* | **implicit** | **traffic** }
16. **protect** { **group** | **vc** }
17. **inarp**
18. **end**
19. Configure the PVC bundle on the peer router.

DETAILED STEPS

	Command or Action	Purpose
Step 1	<p>enable</p> <p>Example:</p> <pre>Router> enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> • Enter your password if prompted.

	Command or Action	Purpose
Step 2	<p>configure terminal</p> <p>Example:</p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
Step 3	<p>ip routing</p> <p>Example:</p> <pre>Router(config)# ip routing</pre>	<p>Enables IP routing.</p>
Step 4	<p>ip cef</p> <p>Example:</p> <pre>Router(config)# ip cef</pre>	<p>Enables Cisco Express Forwarding.</p> <p>Note For the Cisco 7500, enter ip cef distributed.</p>
Step 5	<p>Do one of the following:</p> <ul style="list-style-type: none"> • interface <i>type number</i> • • • interface <i>type number . subinterface-number</i> • multipoint point-to-point <p>Example:</p> <pre>Router(config)# interface serial 0</pre> <p>Example:</p> <p>Example:</p> <pre>Router(config)# interface serial 1.1 multipoint</pre>	<p>Specifies the interface type and number and enters interface configuration mode.</p> <ul style="list-style-type: none"> • Physical interfaces are multipoint subinterfaces by default. <p>or</p> <p>Specifies the interface type and subinterface and enters subinterface configuration mode.</p> <ul style="list-style-type: none"> • Once you create a specific type of subinterface (point-to-point or multipoint), you cannot change it without a reload. To change it, you must either reload the router or create another subinterface.

Command or Action	Purpose
<p>Step 6 encapsulation frame-relay [cisco ietf]</p> <p>Example:</p> <pre>Router(config-if)# encapsulation frame-relay</pre>	<p>Enables Frame Relay encapsulation.</p> <ul style="list-style-type: none"> The default encapsulation method is cisco.
<p>Step 7 ip address <i>ip-address mask</i> [secondary]</p> <p>Example:</p> <pre>Router(config-if)# ip address 10.1.1.1 255.0.0.0</pre>	<p>Sets a primary IP address for the interface.</p> <ul style="list-style-type: none"> The optional secondary keyword specifies that the configured address is a secondary IP address. If this keyword is omitted, the configured address is the primary IP address.
<p>Step 8 frame-relay map <i>protocol protocol-address {dlci vc-bundle vc-bundle-name}</i> [broadcast] [ietf cisco]</p> <p>Example:</p> <pre>Router(config-if)# frame-relay map ip 10.2.2.2 vc-bundle MAIN-1</pre>	<p>(Optional) Maps between a next-hop protocol address and a data-link connection identifier (DLCI) destination address, and creates a PVC bundle if it does not already exist.</p> <ul style="list-style-type: none"> The protocol-address is the destination IP address. The frame-relay map command is required for multipoint interfaces if Inverse ARP has been disabled or is not supported at the other end of the connection.
<p>Step 9 frame-relay vc-bundle <i>vc-bundle-name</i></p> <p>Example:</p> <pre>Router(config-if)# frame-relay vc- bundle MAIN-1</pre>	<p>Creates a PVC bundle if it does not already exist, and enters Frame Relay VC-bundle configuration mode.</p>
<p>Step 10 encapsulation [cisco ietf]</p> <p>Example:</p> <pre>Router(config-fr-vcb)# encapsulation ietf</pre>	<p>(Optional) Overrides the encapsulation type configured on the interface and configures the Frame Relay encapsulation type for the PVC bundle.</p> <ul style="list-style-type: none"> This command is available only when the PVC bundle is configured on a point-to-point subinterface.
<p>Step 11 match {dscp <i>dscp-value</i> precedence <i>precedence-value</i>}</p> <p>Example:</p> <pre>Router(config-fr-vcb)# match precedence 5</pre>	<p>Establishes the type of matching to use between incoming packet headers and PVC-bundle members.</p> <ul style="list-style-type: none"> The default match type is precedence.

Command or Action	Purpose
<p>Step 12 <code>pvc dlc1 [vc-name]</code></p> <p>Example:</p> <pre>Router(config-fr-vcb)# pvc 100 1a</pre>	<p>Creates a PVC-bundle member and enters Frame Relay VC-bundle-member configuration mode.</p> <ul style="list-style-type: none"> The <code>vc-name</code> argument is an optional name that can be used for referring to the PVC.
<p>Step 13 <code>class name</code></p> <p>Example:</p> <pre>Router(config-fr-vcb-vc)# class premium</pre>	<p>(Optional) Assigns a map class to the PVC-bundle member defined in the previous step.</p>
<p>Step 14 Do one of the following:</p> <ul style="list-style-type: none"> <code>precedence {level other}</code> <code>dscp {level other}</code> <p>Example:</p> <pre>Router(config-fr-vcb-vc)# precedence 6-7</pre> <p>Example:</p> <p>Example:</p> <p>Example:</p> <pre>Router(config-fr-vcb-vc)# dscp other</pre>	<p>(Optional) Enters the mapped service level or range for the PVC-bundle member.</p> <ul style="list-style-type: none"> The <code>precedence</code> command is available when the PVC-bundle match type is set to <code>precedence</code>. The precedence range is from 0 to 7. The <code>dscp</code> command is available when the PVC-bundle match type is set to <code>dscp</code>. The <code>dscp</code> range is from 0 to 63. The <code>other</code> keyword is used to designate a PVC to handle all the remaining levels that have not been assigned to other PVCs in the bundle. Critical non-IP traffic will automatically use precedence level 0.

Command or Action	Purpose
<p>Step 15 <code>bump {explicit <i>level</i> implicit traffic}</code></p> <p>Example:</p> <pre>Router(config-fr-vcb-vc)# bump explicit 7</pre>	<p>(Optional) Specifies the bumping rule for the PVC-bundle member.</p> <ul style="list-style-type: none"> The default bumping rule is implicit bumping. Use the explicit <i>level</i> option to specify the service level to which traffic on this PVC will be bumped if the PVC goes down. In that event, the traffic will be directed to a PVC mapped with the service level configured here. If the PVC that picks up and carries the traffic also goes down, the traffic is subject to the bumping rules for that PVC. You can specify only one service level for bumping. The PVC-bundle member accepts bumped traffic by default when the PVC-bundle match type is precedence. To configure the PVC to reject bumped traffic from another PVC-bundle member, use the no bump traffic command.
<p>Step 16 <code>protect {group vc}</code></p> <p>Example:</p> <pre>Router(config-fr-vcb-vc)# protect group</pre>	<p>(Optional) Specifies the protection rule for the PVC-bundle member.</p> <ul style="list-style-type: none"> By default, the PVC-bundle member is not protected. If you use the vc keyword, the PVC bundle goes down whenever this PVC goes down. If you use the group keyword, the PVC bundle goes down when the last PVC in the protected group goes down.
<p>Step 17 <code>inarp</code></p> <p>Example:</p> <pre>Router(config-fr-vcb-vc)# inarp</pre>	<p>(Optional) Enables Inverse ARP for the PVC-bundle member.</p> <ul style="list-style-type: none"> By default, Inverse ARP traffic uses the PVC configured for precedence level 6 or DSCP level 63.
<p>Step 18 <code>end</code></p> <p>Example:</p> <pre>Router(config-fr-vcb-vc)# end</pre>	<p>Exits to privileged EXEC mode.</p>
<p>Step 19 Configure the PVC bundle on the peer router.</p>	<p>(Optional) While it is not necessary to configure a PVC bundle on the peer router, it is recommended that you do so for applications that rely on communications on the same PVC (such as TCP header-compression.)</p>

Configuring Frame Relay PVC Bundles with MPLS QoS Support

To configure Frame Relay PVC bundles for handling MPLS packets, perform the following steps:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip routing**
4. **ip cef**
5. Do one of the following:
 - **interface** *type number*
 -
 -
 -
 - **interface** {*type slot | port-adapter | port.subinterface-number*} [**multipoint | point-to-point**]
6. **encapsulation frame-relay** [**cisco | ietf**]
7. **tag-switching ip**
8. **ip address** *ip-address mask* [**secondary**]
9. **frame-relay map** *protocol protocol-address {dlci| vc-bundle vc-bundle-name}* [**broadcast**] [**ietf cisco**]
10. **frame-relay vc-bundle** *vc-bundle-name*
11. **encapsulation** [**ietf | cisco**]
12. **pvc** *dlci [vc-name]*
13. **class** *name*
14. **exp** {*level | other*}
15. **bump** {**explicit** *level* | **implicit** | **traffic**}
16. **protect** {**group** | **vc**}
17. **inarp**
18. **end**
19. Configure the PVC bundle on the peer router.

DETAILED STEPS

	Command or Action	Purpose
Step 1	<p>enable</p> <p>Example:</p> <pre>Router> enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	<p>configure terminal</p> <p>Example:</p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>

Command or Action	Purpose
<p>Step 3 ip routing</p> <p>Example:</p> <pre>Router(config)# ip routing</pre>	<p>Enables IP routing.</p>
<p>Step 4 ip cef</p> <p>Example:</p> <pre>Router(config)# ip cef</pre>	<p>Enables Cisco Express Forwarding.</p> <p>Note For the Cisco 7500, enter ip cef distributed.</p>
<p>Step 5 Do one of the following:</p> <ul style="list-style-type: none"> • interface <i>type number</i> • • • interface {<i>type slot port-adapter port.subinterface-number</i>} [multipoint point-to-point] <p>Example:</p> <pre>Router(config)# interface serial 0</pre> <p>Example:</p> <p>Example:</p> <p>Example:</p> <p>Example:</p> <pre>Router(config)# interface serial 1.1 multipoint</pre>	<p>Specifies the interface type and number and enters interface configuration mode.</p> <ul style="list-style-type: none"> • Physical interfaces are multipoint subinterfaces by default. <p>or</p> <p>Specifies the interface type and subinterface and enters subinterface configuration mode.</p> <ul style="list-style-type: none"> • Once you create a specific type of subinterface (point-to-point or multipoint), you cannot change it without a reload. To change it, you need to either reload the router or create another subinterface.

	Command or Action	Purpose
Step 6	<p>encapsulation frame-relay [cisco ietf]</p> <p>Example:</p> <pre>Router(config-if)# encapsulation frame-relay</pre>	<p>Enables Frame Relay encapsulation.</p> <ul style="list-style-type: none"> The default encapsulation method is cisco.
Step 7	<p>tag-switching ip</p> <p>Example:</p> <pre>Router(config-if)# tag-switching ip</pre>	<p>Enables label switching of IPv4 packets on an interface.</p>
Step 8	<p>ip address <i>ip-address mask</i> [secondary]</p> <p>Example:</p> <pre>Router(config-if)# ip address 10.1.1.1 255.0.0.0</pre>	<p>Sets a primary IP address for the interface.</p> <ul style="list-style-type: none"> The optional secondary keyword specifies that the configured address is a secondary IP address. If this keyword is omitted, the configured address is the primary IP address.
Step 9	<p>frame-relay map <i>protocol protocol-address {dlci vc-bundle vc-bundle-name}</i> [broadcast] [ietf cisco]</p> <p>Example:</p> <pre>Router(config-if)# frame-relay map ip 10.2.2.2 vc-bundle MAIN-1</pre>	<p>(Optional) Maps between a next-hop protocol address and a DLCI destination address, and creates a PVC bundle if it does not already exist.</p> <ul style="list-style-type: none"> The protocol-address is the destination IP address. The frame-relay map command is required for multipoint interfaces if Inverse ARP has been disabled or is not supported at the other end of the connection.
Step 10	<p>frame-relay vc-bundle <i>vc-bundle-name</i></p> <p>Example:</p> <pre>Router(config-if)# frame-relay vc-bundle MAIN-1</pre>	<p>Creates a PVC bundle if it does not already exist, and enters Frame Relay VC-bundle configuration mode.</p>
Step 11	<p>encapsulation [ietf cisco]</p> <p>Example:</p> <pre>Router(config-fr-vcb)# encapsulation ietf</pre>	<p>(Optional) Overrides the encapsulation type configured on the interface and configures the Frame Relay encapsulation type for the PVC bundle.</p> <ul style="list-style-type: none"> This command is available only when the PVC bundle is configured on a point-to-point subinterface.

Command or Action	Purpose
<p>Step 12 <code>pvc dlc1 [vc-name]</code></p> <p>Example:</p> <pre>Router(config-fr-vcb)# pvc 100 1a</pre>	<p>Creates a PVC-bundle member and enters Frame Relay VC-bundle-member configuration mode.</p> <ul style="list-style-type: none"> The <i>vc-name</i> argument is an optional name that can be used for referring to the PVC.
<p>Step 13 <code>class name</code></p> <p>Example:</p> <pre>Router(config-fr-vcb-vc)# class premium</pre>	<p>(Optional) Assigns a map class to the PVC-bundle member.</p>
<p>Step 14 <code>exp {level other}</code></p> <p>Example:</p> <pre>Router(config-fr-vcb-vc)# exp 6-7</pre>	<p>(Optional) Enters the mapped EXP level or range for the PVC-bundle member.</p> <ul style="list-style-type: none"> The exp command is available only when tag-switching has been enabled. The EXP level values are from 0 to 7. The other keyword is used to designate a PVC to handle all the remaining levels that have not been assigned to other PVCs in the bundle.
<p>Step 15 <code>bump {explicit level implicit traffic}</code></p> <p>Example:</p> <pre>Router(config-fr-vcb-vc)# bump explicit 7</pre>	<p>(Optional) Specifies the bumping rule for the PVC-bundle member defined above.</p> <ul style="list-style-type: none"> The default bumping rule is implicit bumping. Use the explicit level option to specify the EXP level to which traffic on this PVC will be bumped if the PVC goes down. In that event, the traffic will be directed to a PVC mapped with the EXP level configured here. If the PVC that picks up and carries the traffic also goes down, the traffic is subject to the bumping rules for that PVC. You can specify only one EXP level for bumping. To configure the PVC to reject bumped traffic from another PVC-bundle member, use the no bump traffic command.
<p>Step 16 <code>protect {group vc}</code></p> <p>Example:</p> <pre>Router(config-fr-vcb-vc)# protect group</pre>	<p>(Optional) Specifies the protection rule for the PVC-bundle member defined above.</p> <ul style="list-style-type: none"> By default, the PVC-bundle member is not protected. If you use the vc keyword, the PVC bundle goes down whenever this PVC goes down. If you use the group keyword, the PVC bundle goes down when the last PVC in the protected group goes down.

Command or Action	Purpose
Step 17 inarp Example: <pre>Router(config-fr-vcb-vc)# inarp</pre>	(Optional) Enables Inverse ARP for the PVC-bundle member defined above. <ul style="list-style-type: none"> By default, Inverse ARP traffic uses the PVC configured for EXP level 6.
Step 18 end Example: <pre>Router(config-fr-vcb-vc)# end</pre>	(Optional) Exits to privileged EXEC mode.
Step 19 Configure the PVC bundle on the peer router.	(Optional) While it is not necessary to configure a PVC bundle on the peer router, it is recommended that you do so for applications that rely on communications on the same PVC (such as TCP header-compression.)

Verifying Frame Relay PVC Bundles Configuration

To verify the configuration and operation of Frame Relay PVC bundles with QoS support, perform the following optional steps:

SUMMARY STEPS

- enable
- show frame-relay vc-bundle *vc-bundle-name* [detail
- show frame-relay map
- show frame-relay pvc
- show frame-relay ip rtp header-compression [interface *type number*]
- show frame-relay ip tcp header-compression [interface *type number*]
- show adjacency [*type number*] [detail] [summary]

DETAILED STEPS

Command or Action	Purpose
Step 1 enable Example: <pre>Router> enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> Enter your password if prompted.

Command or Action	Purpose
<p>Step 2 <code>show frame-relay vc-bundle <i>vc-bundle-name</i> [detail]</code></p> <p>Example:</p> <pre>Router# show frame-relay vc-bundle mp-3-static</pre>	Displays status, bumping information, protection information, and active and configured precedence or DSCP levels for the PVCs in a PVC bundle.
<p>Step 3 <code>show frame-relay map</code></p> <p>Example:</p> <pre>Router# show frame-relay map</pre>	Displays the current Frame Relay map entries and information about the connections.
<p>Step 4 <code>show frame-relay pvc</code></p> <p>Example:</p> <pre>Router# show frame-relay pvc</pre>	Displays PVC statistics for the PVC-bundle members.
<p>Step 5 <code>show frame-relay ip rtp header-compression [interface <i>type number</i>]</code></p> <p>Example:</p> <pre>Router# show frame-relay ip rtp header-compression</pre>	Displays Frame Relay Real-Time Transport Protocol (RTP) header compression statistics for PVC bundles.
<p>Step 6 <code>show frame-relay ip tcp header-compression [interface <i>type number</i>]</code></p> <p>Example:</p> <pre>Router# show frame-relay ip tcp header-compression serial 1/4</pre>	Displays Frame Relay TCP/IP header compression statistics for PVC bundles.
<p>Step 7 <code>show adjacency [<i>type number</i>] [detail] [summary]</code></p> <p>Example:</p> <pre>Router# show adjacency</pre>	Displays Cisco Express Forwarding adjacency table information.

Monitoring and Maintaining Frame Relay PVC Bundles

To monitor and maintain Frame Relay PVC bundles, perform this task.

SUMMARY STEPS

1. `enable`
2. `debug frame-relay adjacency {pvc[dlci] | vc-bundle [vc-bundle-name]}`
3. `debug frame-relay vc-bundle {detail | state-change} [vc-bundle-name]`

DETAILED STEPS

	Command or Action	Purpose
Step 1	<p><code>enable</code></p> <p>Example:</p> <pre>Router> enable</pre>	<p>Enables higher privilege levels, such as privileged EXEC mode.</p> <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	<p><code>debug frame-relay adjacency {pvc[dlci] vc-bundle [vc-bundle-name]}</code></p> <p>Example:</p> <pre>Router# debug frame-relay adjacency pvc</pre>	<p>Displays information pertaining to an adjacent node that has one or more Frame Relay PVCs or PVC bundles.</p> <ul style="list-style-type: none"> • Use this command to monitor adjacency activity.
Step 3	<p><code>debug frame-relay vc-bundle {detail state-change} [vc-bundle-name]</code></p> <p>Example:</p> <pre>Router# debug frame-relay vc-bundle state-change</pre>	<p>Displays information about the Frame Relay PVC bundles configured on a router.</p> <ul style="list-style-type: none"> • Use this command to monitor state changes and Inverse ARP activity for one or all of the PVC bundles and bundle members configured on a router. <p>Note Using the detail keyword generates a large number of debugs that can quickly fill up a log buffer.</p>

Configuration Examples for Frame Relay PVC Bundles with QoS Support for IP and MPLS

- [PVC Bundles with IP QoS Support on Interfaces Example, page 17](#)
- [PVC Bundle with IP QoS Support with Multiple QoS Parameters Example, page 19](#)
- [PVC Bundle with MPLS QoS Support Example, page 19](#)
- [Verifying Frame Relay PVC Bundle Configuration Examples, page 20](#)
- [Monitoring and Maintaining Frame Relay PVC Bundles Examples, page 22](#)

PVC Bundles with IP QoS Support on Interfaces Example

The following example shows the configuration of five PVC bundles with IP precedence and DSCP mapping. Two bundles are configured on the main interface, one bundle with static mapping and one with

dynamic mapping. Two bundles are configured on a multipoint subinterface, one bundle with static mapping and one with dynamic mapping. One bundle is configured on a point-to-point subinterface.

```

configure terminal
ip routing
ip cef
interface Serial 1/4
  encapsulation frame-relay
  frame-relay intf-type dte
  ip address 10.1.1.1 255.0.0.0
  frame-relay map ip 192.168.2.2 vc-bundle MAIN-1-static
  frame-relay vc-bundle MAIN-1-static
  match precedence
  pvc 100 1a
  precedence other
  pvc 101 1b
  precedence 1
  pvc 102 1c
  precedence 2
  pvc 103 1d
  precedence 3
  pvc 104 1e
  precedence 4
  pvc 105 1f
  precedence 5
  pvc 106 1g
  precedence 6
  pvc 107 1h
  frame-relay vc-bundle MAIN-2-dynamic
  match precedence
  pvc 200
  precedence 0
  pvc 201
  precedence 1
  pvc 202
  precedence 2
  pvc 203
  precedence 3
  pvc 204
  precedence 4
  pvc 205
  precedence 5
  pvc 206
  precedence 6
  pvc 207
  precedence 7
interface Serial 1/4.1 multipoint
  ip address 172.16.1.1 255.0.0.0
  frame-relay map ip 172.17.2.2 vc-bundle MP-3-static
  frame-relay vc-bundle MP-3-static
  match precedence
  pvc 300 3a
  precedence 0
  pvc 301 3b
  precedence 1
  pvc 302 3c
  precedence 2
  pvc 303 3d
  precedence 3
  pvc 304 3e
  precedence 4
  pvc 305 3f
  precedence 5
  pvc 306 3g
  precedence 6
  pvc 307 3h
  precedence 7
interface Serial 1/4.1 multipoint
  frame-relay vc-bundle MP-4-dynamic
  match precedence
  match dscp
  pvc 400 4a

```

```

dscp other
pvc 401 4b
dscp 10-19
pvc 402 4c
dscp 20-29
pvc 403 4d
dscp 30-39
pvc 404 4e
dscp 40-49
pvc 405 4f
dscp 50-59
pvc 406 4g
dscp 60-62
pvc 407 4h
dscp 63
end
interface Serial 1/4.2 point-to-point
ip address 192.168.2.1 255.0.0.0
frame-relay vc-bundle P2P-5
match precedence
pvc 500 5a
precedence 0
pvc 501 5b
precedence 1
pvc 502 5c
precedence 2
pvc 503 5d
precedence 3
pvc 504 5e
precedence 4
pvc 505 5f
precedence 5
pvc 506 5g
precedence 6
pvc 507 5h
precedence 7

```

PVC Bundle with IP QoS Support with Multiple QoS Parameters Example

The following example shows the configuration of a Frame Relay PVC bundle with DSCP-based mapping. The bundle member PVCs are configured with bumping, protection, and other parameters.

```

interface Serial 1/4.2 point-to-point
frame-relay vc-bundle BUNDLE-SEFEN
encapsulation ietf
match dscp
pvc 301
dscp other
bump explicit 45
protect group
class CIR-64000
pvc 302
dscp 40-49
bump explicit 20
no bump traffic
protect vc
inarp
pvc 303
dscp 30-39
bump implicit
protect group

```

PVC Bundle with MPLS QoS Support Example

The following example shows the configuration of four Frame Relay PVC bundle members with MPLS EXP level support in the PVC bundle named "user1".

```

interface serial 0.1 point-to-point

```

```

encapsulation frame-relay
ip address 10.1.1.1
tag-switching ip
frame-relay vc-bundle user1
pvc 100 ny-control
class control
exp 7
protect vc
pvc 101 ny-premium
class premium
exp 6-5
bump explicit 7
no bump traffic
protect group
pvc 102 my-priority
class priority
exp 4-2
protect group
pvc 103 ny-basic
class basic
exp other

protect group

```

Verifying Frame Relay PVC Bundle Configuration Examples

The following examples show output for the commands that can be used to verify Frame Relay PVC bundle configuration.

Sample Output for the show frame-relay vc-bundle Command

The following example shows the Frame Relay PVC bundle named "MP-4-dynamic" with PVC protection applied. Note that in this PVC bundle, DLCI 400 is configured to bump traffic explicitly to the PVC that handles DSCP level 40, which is DLCI 404. All the other DLCIs are configured for implicit bumping. In addition, all the DLCIs are configured to accept bumped traffic.

The asterisk (*) before PVC 4a indicates that this PVC was configured with the **precedence other** command, which means the PVC will handle all levels that are not explicitly configured on other PVCs.

In this example all PVCs are up so the values in the "Active level" fields match the values in the "Config level" fields. If a PVC goes down and its traffic is bumped, the "Active level" field value for the PVC that went down is cleared. The "Active level" field values for the PVC that the traffic bumped to will be updated to include the levels of the PVC that went down.

The first three PVCs in the following example make up a protected group. All three of these PVCs must go down before the bundle will go down. The last two PVCs are protected PVCs: if either of these PVCs go down, the bundle will go down.

```

Router# show frame-relay vc-bundle MP-4-dynamic
MP-4-dynamic on Serial 1/4.1 - Status: UP Match-type: DSCP
Name      DLCI      Config.   Active   Bumping
PG/       CIR      Status
level    level
*4a      400      0-9      0-9      to/accept
up       pg       40/Yes   PV
4b      401      10-19    10-19    9/Yes
pg
4c      402      20-29    20-29    19/Yes
pg
4d      403      30-39    30-39    29/Yes
-
4e      404      40-49    40-49    39/Yes
-
4f      405      50-59    50-59    49/Yes
-
4g      406      60-62    60-62    59/Yes

```

```

pv          up
4h          407      63      63      62/Yes      pv          up
Packets sent out on vc-bundle MP-4-dynamic : 0:
Router#

```

The following example shows the detail output of a PVC bundle. Note in this example that because all packet service levels are not handled, and because the PVCs are currently down, this bundle can never come up.

```

Router# show frame-relay vc-bundle x41 detail
x41 on Serial1/1 - Status: DOWN Match-type: DSCP
Name          DLCI      Config.      Active      Bumping
PG/          CIR      Status      level      to/accept      PV      kbps
              level      level
              410      50-62      49/Yes      -      PV      down
              411      30,32,34,36,3.. 29/Yes
-              down
Packets sent out on vc-bundle x41 : 0
Active configuration and statistics for each member PVC
DLCI      Output pkts      Active level
410      0      50-62
411      0      30,32,34,36,38-40
Router#

```

Sample Output for the show frame-relay map Command

The following sample output displays map and connection information for a PVC bundle called "MAIN-1-static":

```

Router# show frame-relay map
Serial1/4 (up):ip 10.2.2.2 vc-bundle MAIN-1-static, static,
                CISCO, status up

```

Sample Output for the show frame-relay pvc Command

The following sample output indicates that PVC 202 is a member of VC bundle "MAIN-1-static":

```

Router# show frame-relay pvc 202
PVC Statistics for interface Serial1/4 (Frame Relay DTE)
DLCI = 202, DLCI USAGE = LOCAL, PVC STATUS = STATIC, INTERFACE = Serial1/4
  input pkts 0          output pkts 45          in bytes 0
  out bytes 45000      dropped pkts 0          in FECN pkts 0
  in BECN pkts 0      out FECN pkts 0        out BECN pkts 0
  in DE pkts 0         out DE pkts 0
  out bcast pkts 0     out bcast bytes 0
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 2000 bits/sec, 2 packets/sec
  pvc create time 00:01:25, last time pvc status changed 00:01:11
  VC-Bundle MAIN-1-static

```

Sample Output for the show adjacency Command

The following is sample output for the **show adjacency** command for a PVC bundle configured on serial subinterface 1/4.1. Each bundle member is listed. The bundle itself is indicated by "incomplete" because no traffic actually transmitted on that entry.

```

Router# show adjacency
Protocol Interface      Address
IP       Serial1/4.1        10.2.2.2(4)
IP       Serial1/4.1        10.2.2.2(4)
IP       Serial1/4.1        10.2.2.2(4)
IP       Serial1/4.1        10.2.2.2(4)
IP       Serial1/4.1        10.2.2.2(4)
IP       Serial1/4.1        10.2.2.2(4)
IP       Serial1/4.1        10.2.2.2(4)

```

```

IP          Serial1/4.1          10.2.2.2(4)
IP          Serial1/4.1          10.2.2.2(5) (incomplete)

```

Monitoring and Maintaining Frame Relay PVC Bundles Examples

The following examples show output for the **debug frame-relay adjacency** and **debug frame-relay vc-bundle** commands, which can be used to troubleshoot Frame Relay PVC bundle operation. "FR-VCB" indicates output from the **debug frame-relay vc-bundle** command, and "FR-ADJ" indicates output from the **debug frame-relay adjacency** command.



Note

Debug messages that are prefixed with "FR_ADJ" (instead of FR-ADJ) or "FR_VCB" (instead of "FR-VCB") indicate serious failures in the Frame Relay PVC bundle performance. Contact the Cisco Technical Assistance Center (TAC) if you see debug messages with these prefixes.

The following is sample output that shows a PVC bundle that uses static map coming up. PVC bundle member 100 comes up first, then the PVC bundle itself can come up.

```

Router# debug frame-relay vc-bundle state-change
Router# debug frame-relay adjacency vc-bundle

00:35:58:FR-VCB:MAIN-1-static:member 100 state changed to UP 00:35:58:FR-VCB:MAIN-1-
static:state changed to UP
00:35:58:FR-ADJ:vcb MAIN-1-static:ip 10.2.2.2:adding primary adj
00:35:58:FR-ADJ:vcb MAIN-1-static:member 100:adding adj
00:35:58:FR-ADJ:vcb MAIN-1-static:member 100:locking adj at index 0 00:35:58:FR-ADJ:vcb
MAIN-1-static:member 100:locking adj at index 1
00:35:58:FR-ADJ:vcb MAIN-1-static:member 100:locking adj at index 2
00:35:58:FR-ADJ:vcb MAIN-1-static:member 100:locking adj at index 3
00:35:58:FR-ADJ:vcb MAIN-1-static:member 100:locking adj at index 4
00:35:58:FR-ADJ:vcb MAIN-1-static:member 100:locking adj at index 5
00:35:58:FR-ADJ:vcb MAIN-1-static:member 100:locking adj at index 6
00:35:58:FR-ADJ:vcb MAIN-1-static:member 100:locking adj at index 7
00:35:58:%FR-5-DLCICHANGE:Interface Serial1/4 - DLCI 100 state changed to ACTIVE
00:35:58:FR-VCB:MAIN-1-static:member 101 state changed to UP
00:35:58:FR-ADJ:vcb MAIN-1-static:ip 10.2.2.2:updating primary adj
00:35:58:FR-ADJ:vcb MAIN-1-static:member 100:updating adj
00:35:58:FR-ADJ:vcb MAIN-1-static:member 101:adding adj
00:35:58:FR-ADJ:vcb MAIN-1-static:member 100:unlocking adj at index 1
00:35:58:FR-ADJ:vcb MAIN-1-static:member 101:locking adj at index 1

```

The following is sample output that shows a PVC bundle going down. Each bundle member PVC is marked for removal from Cisco Express Forwarding adjacency table, and then the adjacency for the PVC bundle itself is marked for removal. The adjacencies are actually removed from the table later when a background clean-up process runs.

```

00:38:35:FR-VCB:MP-3-static:state changed to DOWN
00:38:35:FR-ADJ:vcb MP-3-static:ip 172.17.2.2:member 300:removing adj
00:38:35:FR-ADJ:vcb MP-3-static:ip 172.17.2.2:member 301:removing adj
00:38:35:FR-ADJ:vcb MP-3-static:ip 172.17.2.2:member 302:removing adj
00:38:35:FR-ADJ:vcb MP-3-static:ip 172.17.2.2:member 303:removing adj
00:38:35:FR-ADJ:vcb MP-3-static:ip 172.17.2.2:member 304:removing adj
00:38:35:FR-ADJ:vcb MP-3-static:ip 172.17.2.2:member 305:removing adj
00:38:35:FR-ADJ:vcb MP-3-static:ip 172.17.2.2:removing primary adj

```

The following is sample output that shows Inverse ARP information for the PVC bundle. PVC bundle member 406 is the only PVC in the bundle to handle Inverse ARP packets. The Inverse ARP packets coming in on other bundle member PVCs are dropped.

```

00:23:48:FR-VCB:MP-4-dynamic:inarp received on elected member 406
00:23:48:FR-VCB:MP-4-dynamic:installing dynamic map

```

```
00:23:48:FR-VCB:MP-4-dynamic:dropping inarp received on member 407
00:23:52:FR-VCB:MP-4-dynamic:sending inarp pkt on member 406
```

In the following example the PVC bundle goes down because the protected group goes down. All information about active transmission on each PVC is removed.

```
00:58:27:FR-VCB:MP-4-dynamic:member 402 state changed to DOWN
00:58:27:FR-VCB:MP-4-dynamic:protected group is DOWN
00:58:27:FR-VCB:MP-4-dynamic:state changed to DOWN
00:58:27:FR-VCB:MP-4-dynamic:active table reset
```

Additional References

Related Documents

Related Topic	Document Title
Frame Relay configuration tasks	<i>"Configuring Frame Relay chapter in the Cisco IOS Wide-Area Networking Configuration Guide , Release 12.2</i>
Frame Relay commands	<i>"Frame Relay Commands chapter in the Cisco IOS Wide-Area Networking Command Reference , Release 12.2</i>
Frame Relay PVC interface priority queueing configuration tasks	<i>"Configuring Weighted Fair Queueing " section in the Congestion Management chapter in the Cisco IOS Quality of Service Configuration Guide , Release 12.2</i>

Standards

Standards	Title
None	--

MIBs

MIBs	MIBs Link
None	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFCs	Title
None	--

Technical Assistance

Description	Link
The Cisco Technical Support & Documentation website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/techsupport

Feature Information for Frame Relay PVC Bundles with QoS Support for IP and MPLS

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 1 Feature Information for Frame Relay PVC Bundles with QoS Support for IP and MPLS

Feature Name	Releases	Feature Information
Frame Relay VC Bundling	12.2(13)T 12.2(28)SB 15.0(1)S	<p>Frame Relay permanent virtual circuit (PVC) bundle functionality allows you to associate a group of Frame Relay PVCs with a single next-hop address.</p> <p>The following commands were introduced or modified: bump (Frame Relay VC-bundle-member), class, debug frame-relay adjacency, debug frame-relay vc-bundle, dscp (Frame Relay VC-bundle-member), encapsulation (Frame Relay VC-bundle), exp, frame-relay inverse-arp, frame-relay map, frame-relay vc-bundle, inarp (Frame Relay VC-bundle-member), match, precedence (Frame Relay VC-bundle-member), protect (Frame Relay VC-bundle-member), pvc (Frame Relay VC-bundle), show frame-relay ip rtp header-compression, show frame-relay ip tcp header-compression, show frame-relay map, show frame-relay pvc, show frame-relay vc-bundle..</p>

Glossary

DLCI --data-link connection identifier. Value that specifies a permanent virtual circuit (PVC) or switched virtual circuit (SVC) in a Frame Relay network.

FIFO queueing -- First-in, first-out queueing. FIFO involves buffering and forwarding of packets in the order of arrival. FIFO embodies no concept of priority or classes of traffic. There is only one queue, and all packets are treated equally. Packets are sent out an interface in the order in which they arrive.

Frame Relay traffic shaping --See FRTS.

FRF.12 --The FRF.12 Implementation Agreement was developed to allow long data frames to be fragmented into smaller pieces and interleaved with real-time frames. In this way, real-time voice and nonreal-time data frames can be carried together on lower-speed links without causing excessive delay to the real-time traffic.

FRTS --Frame Relay traffic shaping. FRTS uses queues on a Frame Relay network to limit surges that can cause congestion. Data is buffered and then sent into the network in regulated amounts to ensure that the traffic will fit within the promised traffic envelope for the particular connection.

PIPQ --Permanent virtual circuit (PVC) interface priority queueing. An interface-level priority queueing scheme in which prioritization is based on destination PVC rather than packet contents.

quality of service --Measure of performance for a transmission system that reflects its transmission quality and service availability.

VoFR --Voice over Frame Relay. Enables a router to carry voice traffic over a Frame Relay network. When voice traffic is sent over Frame Relay, the voice traffic is segmented and encapsulated for transit across the Frame Relay network using FRF.12 encapsulation.

Voice over Frame Relay --See VoFR.

WFQ --weighted fair queueing. Congestion management algorithm that identifies conversations (in the form of traffic streams), separates packets that belong to each conversation, and ensures that capacity is shared fairly among these individual conversations. WFQ is an automatic way of stabilizing network behavior during congestion and results in increased performance and reduced retransmission.

WRED --Weighted Random Early Detection. Combines IP Precedence and standard Random Early Detection (RED) to allow for preferential handling of voice traffic under congestion conditions without exacerbating the congestion. WRED uses and interprets IP Precedence to give priority to voice traffic over data traffic, dropping only data packets.

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