Configuring Frame Relay

Frame Relay is a high-performance Wide Area Network (WAN) protocol that operates at the physical and data link layers. The Cisco IOS XE Frame Relay implementation currently supports routing for IPv4, IPv6, and Multiprotocol Label Switching (MPLS).

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and 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.

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

Restrictions for Configuring Frame Relay

Cisco IOS XE software does not support the following:

- Multipoint permanent virtual circuits (PVCs)
- Switched virtual circuits (SVCs)
- Frame relay switching
- 4-byte extended addresses
- End-to-end keepalives
- FRF.9 payload compression

- Data stream compression
- Packet by packet encapsulation payload compression
- Multi-point frame-relay
- Legacy frame-relay traffic shaping (Cisco IOS XE software supports only policy map-based MQC.)
- MQC based frame relay traffic shaping is not supported on frame relay main interface.
- Function "set fr-de" for HQos configuration

Information About Frame Relay

Frame Relay Hardware Configurations

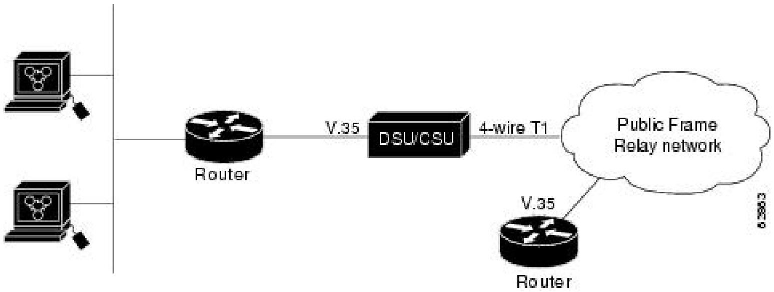
You can create Frame Relay connections using one of the following hardware configurations:

- Devices and access servers connected directly to the Frame Relay switch
- Devices and access servers connected directly to a channel service unit/digital service unit (CSU/DSU), which then connects to a remote Frame Relay switch

Note Devices can connect to Frame Relay networks either by direct connection to a Frame Relay switch, through a direct connection to a Point of sale (POS) interface or a T1/T3 interface, or through CSU/DSUs. However, a single device interface configured for Frame Relay can be configured for only one of these methods.

The CSU/DSU converts V.35 or RS-449 signals to the properly coded T1 transmission signal for successful reception by the Frame Relay network. The figure below illustrates the connections among the components.

Figure 1: Typical Frame Relay Configuration



The Frame Relay interface actually consists of one physical connection between the network server and the switch that provides the service. This single physical connection provides direct connectivity to each device on a network.

Frame Relay Encapsulation

Frame Relay supports encapsulation of all supported protocols in conformance with RFC 1490, *Multiprotocol Interconnect over Frame Relay*, allowing interoperability among multiple vendors. Use the IETF form of Frame Relay encapsulation if your device or access server is connected to another vendor's equipment across a Frame Relay network. IETF encapsulation is supported either at the interface level or on a per-VC basis.

Shut down the interface prior to changing encapsulation types. Although shutting down the interface is not required, it ensures that the interface is reset for the new encapsulation.

Dynamic or Static Address Mapping

Dynamic Address Mapping

Dynamic address mapping uses Frame Relay Inverse Address Resolution Protocol (ARP) to request the next-hop protocol address for a specific connection, given its known Data link connection identifier (DLCI). Responses to Inverse ARP requests are entered in an address-to-DLCI mapping table on the device or access server. The DLCI mapping table is then used to supply the next-hop protocol address or the DLCI for outgoing traffic.

Inverse ARP is enabled by default for all protocols it supports. However, it can be disabled for specific protocol-DLCI pairs. As a result, you can use dynamic mapping for some protocols and static mapping for other protocols on the same DLCI. You can explicitly disable Inverse ARP for a protocol-DLCI pair if you know that the protocol is not supported on the other end of the connection. For more information, see the Disabling or Reenabling Frame Relay Inverse ARP section.

Note Because Inverse ARP is enabled by default, no additional command is required to configure dynamic mapping on an interface and packets are not sent out for protocols that are not enabled on the interface.

Static Address Mapping

A static map links a specified next-hop protocol address to a specified Data link connection identifier (DLCI). Static mapping removes the need for Inverse Address Resolution Protocol (ARP) requests; when you supply a static map, Inverse ARP is automatically disabled for the specified protocol on the specified DLCI. You must use static mapping in the any of the following scenarios:

- If the device at the other end does not support Inverse ARP at all
- If the device does not support Inverse ARP for a specific protocol that you want to use over Frame Relay.

You can simplify the configuration for the Open Shortest Path First (OSPF) protocol by adding the optional **broadcast** keyword when doing this task. Refer to the **frame-relay map** command description in the *Cisco IOS Wide-Area Networking Command Reference* and the examples at the end of this chapter for more information about using the **broadcast** keyword.

LMI

The software supports Local Management Interface (LMI) autosense, which enables the interface to determine the LMI type supported by the switch. Support for LMI autosense means that you need not configure the LMI explicitly.

LMI autosense is active in the following situations:

- The device is powered up or the interface changes state to up.
- The line protocol is down but the line is up.
- The interface is a Frame Relay Data Terminal Equipment (DTE).
- The LMI type is not explicitly configured.

Activating LMI Autosense

Status Request

When Local Management Interface (LMI) autosense is active, it sends out a full status request in all three LMI types to the switch. The order which is implemented in rapid succession is as follows:

- ANSI
- ITU
- Cisco

software provides the ability to listen in on both DLCI 1023 (cisco LMI) and DLCI 0 (ANSI and ITU) simultaneously.

Status Messages

One or more of the status requests will prompts a reply (status message) from the switch. The device decodes the format of the reply and configures itself automatically. If more than one reply is received, the device configures itself with the type of the last received reply. This is to accommodate intelligent switches that can handle multiple formats simultaneously.

LMI Autosense

If Local Management Interface (LMI) autosense is unsuccessful, an intelligent retry scheme is built in. Every N391 interval (default is 60 seconds, which is 6 keep exchanges at 10 seconds each), LMI autosense attempts to ascertain the LMI type. For more information about N391, see the **frame-relay lmi-n391dte** command in the chapter "Frame Relay Commands " in the *Cisco IOS Wide-Area Networking Command Reference* .

The only visible indication to the user that LMI autosense is in progress is that **debug frame lmi** is enabled. At every N391 interval, the user sees 3 rapid status inquiries from the serial interface one in each of the following LMI-type:

- ANSI
- ITU
- Cisco

Configuration Options

No configuration options are provided; LMI autosense is transparent to the user. You can turn off LMI autosense by explicitly configuring an Local Management Interface (LMI) type. The LMI type must be written into NVRAM so that next time the device powers up, LMI autosense will be inactive. At the end of autoinstall, a **frame-relay lmi-type** *xxx* statement is included within the interface configuration. This configuration is not automatically written to NVRAM; you must explicitly write the configuration to NVRAM by using the **copy system:running-config** or **copy nvram:startup-config** command.

MQC-Based Frame Relay Traffic Shaping

Legacy frame-relay traffic shaping is not supported. Cisco IOS XE software only supports policy map based MQC.

Traffic-Shaping Map Class for the Interface

If you specify a Frame Relay map class for a main interface, all the virtual circuits (VCs) on its subinterfaces inherit all the traffic-shaping parameters defined for the class. You can override the default for a specific data link connection identifier (DLCI) on a specific subinterface by using the **class** VC configuration command to assign the DLCI explicitly to a different class. For information about setting up subinterfaces, refer the section Configuring Frame Relay Subinterfaces, on page 17 .

Specifying Map Class with Queueing and Traffic-Shaping Parameters

When defining a map class for Frame Relay, you can specify the average and peak rates (in bits per second) allowed on virtual circuits (VCs) associated with the map class. You can also specify *either* a custom queue list *or* a priority queue group to use on VCs associated with the map class.

Defining Access Lists

You can specify access lists and associate them with the custom queue list defined for any map class. The list number specified in the access list and the custom queue list tie them together. See the appropriate protocol chapters for information about defining access lists for the protocols you want to transmit on the Frame Relay network.

Understanding Frame Relay Subinterfaces

Frame Relay subinterfaces provide a mechanism for supporting partially meshed Frame Relay networks. Most protocols assume transitivity on a logical network; that is, if station A can communicate with station B, and station B can communicate to station C, then station A should be able to communicate to station C directly. Transitivity is true on LANs, but not on Frame Relay networks unless A is directly connected to C.

Additionally, certain protocols such as AppleTalk and transparent bridging are not supported on partially meshed networks because they require *split horizon* . Split horizon is a routing technique in which a packet received on an interface cannot be sent from the same interface even if received and transmitted on different virtual circuits (VCs) .

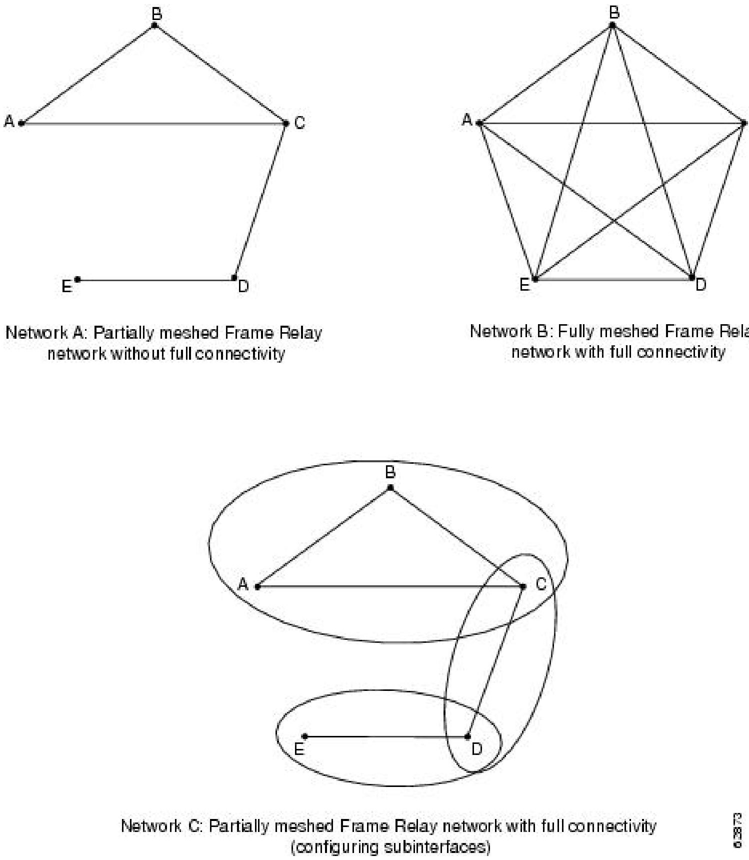
Configuring Frame Relay subinterfaces ensures that a single physical interface is considered as multiple virtual interfaces. Hence, packets received on one virtual interface can be forwarded to another virtual interface even if they are configured on the same physical interface.

Subinterfaces address the limitations of Frame Relay networks by providing an option to subdivide a partially meshed Frame Relay network into a number of smaller, fully meshed (or point-to-point) subnetworks. Each subnetwork is assigned its own network number and appears to the protocols as if it were reachable through a separate interface. (Note that point-to-point subinterfaces can be unnumbered for use with IP, thus reducing the addressing burden that might otherwise result.)

Note Cisco IOS XE software supports configuration of point-to-point subinterfaces.

The figure below shows a five-node Frame Relay network that is partially meshed (network A). If the entire network is viewed as a single subnetwork (with a single network number assigned), most protocols assume that node A can transmit a packet directly to node E, when, in fact it must be relayed through nodes C and D. This network can work with certain protocols (for example, IP). However, this network does not work with other protocols (for example, AppleTalk), because nodes C and D do not relay the packet out at the same interface on which it was received. To make this network fully functional, we need to created a fully meshed network (network B). However, a fully meshed network requires a large number of permanent virtual circuits (PVCs), which may not be economically feasible.

Figure 2: Using Subinterfaces to Provide Full Connectivity on a Partially Meshed Frame Relay Network



Network A: Partially meshed Frame Relay network without full connectivity

Network B: Fully meshed Frame Relay network with full connectivity

Network C: Partially meshed Frame Relay network with full connectivity (configuring subinterfaces)

By using subinterfaces, you can divide the Frame Relay network into 3 smaller subnetworks (network C) with separate network numbers. Nodes A, B, and C are connected to a fully meshed network, and nodes C and D, as well as nodes D and E, are connected via point-to-point networks. In this configuration, nodes C and D can access 2 subinterfaces and can therefore forward packets without violating split horizon rules. If transparent bridging is being used, each subinterface is viewed as a separate bridge port.

Subinterface Addressing

For point-to-point subinterfaces, the destination is presumed to be known and is identified or implied in the **frame-relay interface-dlci** command.

Note The **frame-relay interface-dlci** command is typically used on subinterfaces; however, it can also be applied to main interfaces. The command is used to enable routing protocols on main interfaces that are configured to use Inverse ARP. This command is also helpful for assigning a specific class to a single permanent virtual circuit (PVC) on a multipoint subinterface.

If you define a subinterface for point-to-point communication, you cannot reassign the same subinterface number to be used for multipoint communication without first rebooting the device or access server. Instead, you can simply avoid using that subinterface number and use a different subinterface number.

Backup Interface for a Subinterface

Both point-to-point and multipoint Frame Relay subinterfaces can be configured with a backup interface. This approach allows individual permanent virtual circuit (PVCs) to be backed up in case of failure rather than depending on the entire Frame Relay connection to fail before the backup takes over. You can configure a subinterface for backup on failure only, not for backup based on loading of the line.

If the main interface has a backup interface, it has a precedence over the backup interface of the subinterface in the case of complete loss of connectivity with the Frame Relay network. As a result, a subinterface backup is activated only in the following cases:

- If the main interface is up
- If the interface is down and does not have a backup interface defined

If a subinterface fails while its backup interface is in use, and the main interface goes down, the backup subinterface remains connected.

Disabling or Reenabling Frame Relay Inverse ARP

Frame Relay Inverse Address Resolution Protocol (ARP) is a method of building dynamic address mappings in Frame Relay networks that run DECnet, IP, and Novell IPX. Inverse ARP allows the device or access server to discover the protocol address of a device associated with the virtual circuit (VC).

Inverse ARP creates dynamic address mappings, as contrasted with the **frame-relay map** command, which defines static mappings between a specific protocol address and a specific data link connection identifier (DLCI) (see the section Configuring Static Address Mapping, on page 12 for more information).

Inverse ARP is enabled by default but can be disabled explicitly for a given protocol and DLCI pair. Disable or reenable Inverse ARP under the following conditions:

- Disable Inverse ARP for a selected protocol and DLCI pair when you know that the protocol is not supported at the other end of the connection.

- Reenable Inverse ARP for a protocol and DLCI pair if conditions or equipment change and the protocol is then supported at the other end of the connection.

Note If you change from a point-to-point subinterface to a multipoint subinterface, change the subinterface number. Frame Relay Inverse ARP will be on by default, and no further action is required.

You do not need to enable or disable Inverse ARP if you have a point-to-point interface.

Frame Relay Fragmentation

End-to-End FRF.12 Fragmentation

The purpose of end-to-end Frame Relay Fragmentation 12 (FRF.12) is to support real-time and non-real-time data packets on lower-speed links without causing excessive delay to the real-time data transmission. FRF.12 fragmentation is defined by the FRF.12 Implementation Agreement. This standard was developed to allow long data frames to be fragmented into smaller pieces (fragments) and interleaved with real-time frames. In this way, real-time and non-real-time data frames can be carried together on lower-speed links without causing excessive delay to the real-time traffic.

End-to-end FRF.12 fragmentation is recommended for use on permanent virtual circuits (PVCs) that share links with other PVCs that are transporting voice and on PVCs transporting Voice over IP (VoIP). Although VoIP packets should not be fragmented, they can be interleaved with fragmented packets.

FRF.12 is configured on a per-PVC basis using a Frame Relay map class. The map class can be applied to one or many PVCs. Frame Relay traffic shaping must be enabled on the interface for fragmentation.

Note When Frame Relay fragmentation is configured, Weighted Fair Queuing (WFQ) or Low Latency Queuing (LLQ) is mandatory. If a map class is configured for Frame Relay fragmentation and the queuing type on that map class is not WFQ or LLQ, the configured queueing type is automatically overridden by WFQ with the default values. To configure LLQ for Frame Relay, refer to the *Cisco IOS XE Quality of Service Solutions Configuration Guide* .

Setting the Fragment Size

Set the fragment size so that voice packets are not fragmented and do not experience a serialization delay greater than 20 ms.

To set the fragment size, the link speed must be taken into account. The fragment size should be larger than the voice packets, but small enough to minimize latency on the voice packets. Turn on fragmentation for low speed links (less than 768 kbps).

Set the fragment size based on the lowest port speed between the routers. For example, if there is a hub and spoke Frame Relay topology where the hub has a T1 speed and the remote routers have 64 kbps port speeds, the fragment size needs to be set for the 64 kbps speed on both routers. Any other PVCs that share the same physical interface need to configure the fragmentation to the size used by the voice PVC.

If the lowest link speed in the path is 64 kbps, the recommended fragment size (for 10 ms serialization delay) is 80 bytes. If the lowest link speed is 128 kbps, the recommended fragment size is 160 bytes.

For more information, refer to the " Fragmentation (FRF.12)" section in the VoIP over Frame Relay with Quality of Service (Fragmentation, Traffic Shaping, LLQ / IP RTP Priority) document.

TCP IP Header Compression

TCP/IP header compression, as described by RFC 1144, *Compressing TCP/IP Headers for Low-Speed Serial Links* is designed to improve the efficiency of bandwidth utilization over low-speed serial links. A typical TCP/IP packet includes a 40-byte datagram header. Once a connection is established, the header information is redundant and need not be repeated in every packet that is sent. Reconstructing a smaller header that identifies the connection, indicates the fields that have changed and the amount of change reduces the number of bytes transmitted. The average compressed header is 10 bytes long.

For this algorithm to function, packets must arrive in order. If packets arrive out of order, the reconstruction will appear to create regular TCP/IP packets but the packets will not match the original. Because priority queueing changes the order in which packets are transmitted, enabling priority queueing on the interface is not recommended.

Note If you configure an interface with Cisco-proprietary encapsulation and TCP/IP header compression, Frame Relay IP maps inherit the compression characteristics of the interface. However, if you configure the interface with IETF encapsulation, the interface cannot be configured for compression. Frame Relay maps will have to be configured individually to support TCP/IP header compression.

Specifying an Individual IP Map for TCP IP Header Compression

Note An interface configured to support TCP/IP header compression does not also support priority queuing or custom queuing.

TCP/IP header compression requires Cisco-proprietary encapsulation. If you need to have IETF encapsulation on an interface as a whole, you can still configure a specific IP map to use Cisco-proprietary encapsulation and TCP header compression. In addition, if you configure the interface to perform TCP/IP header compression, you can still configure a specific IP map not to compress TCP/IP headers.

You can specify whether TCP/IP header compression is active or passive. Active compression subjects every outgoing packet to TCP/IP header compression. Passive compression subjects an outgoing TCP/IP packet to header compression only if a packet had a compressed TCP/IP header when it was received.

Specifying an Interface for TCP IP Header Compression

You can configure the interface with an active or passive TCP/IP header compression. Active compression, the default, subjects all outgoing TCP/IP packets to header compression. Passive compression subjects an outgoing packet to header compression only if the packet had a compressed TCP/IP header when it was received on that interface.

Note If an interface configured with Cisco-proprietary encapsulation is later configured with IETF encapsulation, all TCP/IP header compression characteristics are lost. To apply TCP/IP header compression over an interface configured with IETF encapsulation, you must configure individual IP maps, as described in the *Configuring an Individual IP Map for TCP IP Header Compression* section.

Real-Time Header Compression with Frame Relay Encapsulation

Real-time Transport Protocol (RTP) is a protocol used for carrying packetized audio and video traffic over an IP network. It provides end-to-end network transport functions intended for these real-time traffic applications and multicast or unicast network services. RTP is described in RFC 1889,*A Transport Protocol for Real-Time Applications* . RTP is not intended for data traffic, which uses TCP or UDP.

For configuration tasks and examples of RTP header compression using Frame Relay encapsulation, see the *Cisco IOS XE IP Multicast Configuration Guide* .

The commands for configuring this feature are available in the *Cisco IOS IP Multicast Command Reference.*

Discard Eligibility

Frame Relay packets can be set with low priority or low time sensitivity. These packets will be the first to be dropped when a Frame Relay switch is congested. The mechanism that allows a Frame Relay switch to identify such packets is the discard eligibility (DE) bit.

Discard eligibility requires the Frame Relay network to be able to interpret the DE bit. Some networks take no action when the DE bit is set, and others use the DE bit to determine which packets to discard. The best interpretation is to use the DE bit to determine which packets should be dropped first and also which packets have lower time sensitivity.

You can create DE lists that identify the characteristics of packets to be eligible for discarding, and you can also specify DE groups to identify the data link connection identifier (DLCI) that is affected.

You can create DE lists based on the protocol or the interface, and on characteristics such as fragmentation of the packet, a specific TCP or UDP port, an access list number, or a packet size.

DLCI Priority Levels

Data Link Connection Identifier (DLCI) priority levels allow you to separate different types of traffic and provides a traffic management tool for congestion problems caused by the following:

- Mixing batch and interactive traffic over the same DLCI
- Queuing traffic from sites with high-speed access to destination sites with lower-speed access

Before you configure the DLCI priority levels, you must:

- Enable Frame Relay encapsulation.
- Define dynamic or static address mapping.
- Ensure that you define each of the DLCIs to which you intend to apply levels. You can associate priority-level DLCIs with subinterfaces.
- Configure the LMI.

Note DLCI priority levels provide a way to define multiple parallel DLCIs for different types of traffic. DLCI priority levels do not assign priority queues within the device or access server. In fact, they are independent of the priority queues of the device. However, if you enable queuing and use the same DLCIs for queuing, then high-priority DLCIs can be put into high-priority queues.

How to Configure Frame Relay

Enabling Frame Relay Encapsulation on an Interface

Note Frame Relay encapsulation is a prerequisite for any Frame Relay commands on an interface.

To enable Frame Relay encapsulation on the interface level, use the following commands beginning in global configuration mode:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *typenumber*
4. **encapsulation frame-relay**[**ietf**]
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *typenumber* **Example:** `Device(config)# int ethernet 0/1`	Specifies the interface, and enters interface configuration mode.
Step 4	**encapsulation frame-relay**[**ietf**] **Example:** `Device(config-if)# encapsulation frame-relay ietf`	Enables and specifies the Frame Relay encapsulation method.

Step 5	**end**
	Example:
	`Device(config-if)# end`
		Returns to privileged EXEC mode.

Configuring Static Address Mapping

To establish static mapping according to your network requirements, use the following command in interface configuration mode:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *typenumber*
4. **frame-relay map** *protocol protocol-address dlci* [**broadcast**] [**ietf**] [**cisco**]
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *typenumber* **Example:** `Device(config)# int ethernet 0/1`	Specifies the interface, and enters interface configuration mode.
Step 4	**frame-relay map** *protocol protocol-address dlci* [**broadcast**] [**ietf**] [**cisco**] **Example:** `Device(config-if)#`	Enables and specifies the Frame Relay encapsulation method.

Step 5	**end**
	Example:
	`Device(config-if)# end`
		Returns to privileged EXEC mode.

Explicitly Configuring the LMI

Setting the LMI Type

If the device or access server is attached to a public data network (PDN), the LMI type must match the type used on the public network. Otherwise, the LMI type can be set to suit the requirements of your private Frame Relay network. You can set one of the following three types of LMIs on Cisco devices:

- ANSI T1.617 Annex D
- Cisco
- ITU-T Q.933 Annex A

To do so, use the following commands beginning in interface configuration mode:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *typenumber*
4. **frame-relay lmi-type** {**ansi** | **cisco** | **q933a**}
5. **end**
6. **copy nvram:startup-config** *destination*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *typenumber* **Example:** `Device(config)# int ethernet 0/1`	Specifies the interface, and enters interface configuration mode.

Step 4	**frame-relay lmi-type** {**ansi** | **cisco** | **q933a**}
	Example:
	`Device(config-if)#`
		Sets the LMI type.

Step 5	**end** **Example:**	Returns to privileged EXEC mode.

	Command or Action	Purpose
	`Device(config-if)# end`	
Step 6	**copy nvram:startup-config** *destination* **Example:** `Device#`	Writes the LMI type to NVRAM.

Setting the LMI Keepalive Interval

A keepalive interval must be set to configure the Local Management Interface (LMI). By default, this interval is 10 seconds. According to the LMI protocol, the keepalive interval must be less than the corresponding interval on the switch. To set the keepalive interval, use the following command in interface configuration mode:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *typenumber*
4. **keepalive** *keepalive period*
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *typenumber* **Example:** `Device(config)# int ethernet 0/1`	Specifies the interface, and enters interface configuration mode.
Step 4	**keepalive** *keepalive period* **Example:** `Device(config-if)# keepalive 300`	Sets the keepalive interval. • *keepalive period*- Valid range is from 0 to 32767. **Note** To disable keepalives on networks that do not utilize LMI, use the **no keepalive** command.

	Command or Action	Purpose

Step 5	**end**
	Example:
	`Device(config-if)# end`
		Returns to privileged EXEC mode.

Setting the LMI Polling and Timer Intervals

You can set various optional counters, intervals, and thresholds to fine-tune the operation of your Local Management Interface data terminal equipment (LMI DTE) and data communications equipment (DCE) devices. Set these attributes by using one or more of the following commands in interface configuration mode:

Command	Purpose
frame-relay lmi-n392dce *threshold*	Sets the DCE and Network-to-Network Interface (NNI) error threshold.
frame-relay lmi-n393dce *events*	Sets the DCE and NNI monitored events count.
frame-relay lmi-t392dce *seconds*	Sets the polling verification timer on a DCE or NNI interface.
frame-relay lmi-n391dte *keep-exchanges*	Sets a full status polling interval on a DTE or NNI interface.
frame-relay lmi-n392dte *threshold*	Sets the DTE or NNI error threshold.
frame-relay lmi-n393dte *events*	Sets the DTE and NNI monitored events count.

Configuring MQC-Based Frame Relay Traffic Shaping

Specifying a Traffic-Shaping Map Class for the Interface

To specify a map class for the specified interface, use the following command beginning in interface configuration mode:

SUMMARY STEPS

1. Router(config-if)# **frame-relay class** *map-class-name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	Router(config-if)# **frame-relay class** *map-class-name*	Specifies a Frame Relay map class for the interface.

Defining a Map Class with Queueing and Traffic-Shaping Parameters

To define a map class, use the following commands beginning in global configuration mode:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **policy-map** *policy-map-name*
4. **class class-default**
5. **bandwidth** {*bandwidth-in-kbps* | **remaining** | **percent** }
6. **priority** [*bandwidth-in-kbps* | **level** | **percent**]
7. **shape average** {*rate-in-bps* |**percent**}
8. **shape adaptive** *rate-in-bps*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**policy-map** *policy-map-name* **Example:** `Device(config)# policy-map testmap`	Specifies a policy map to define and enters policy map configuration mode.

Step 4	**class class-default**
	Example:
	`Device(config-pmap)# class class-default`
		Specifies a system default class and enters policy-map class configuration .

Step 5	**bandwidth** {*bandwidth-in-kbps* | **remaining** | **percent** }
	Example:
	`Device(config-pmap-c)#  bandwidth 50`
		Configures a minimum bandwidth guarantee for a class.

Step 6	**priority** [*bandwidth-in-kbps* | **level** | **percent**] **Example:** `Device(config-pmap-c)# priority 150`	Assigns priority to a class of traffic belonging to a policy map.

Step 7	**shape average** {*rate-in-bps* |**percent**}
	Example:
	`Device(config-pmap-c)# shape average 8000`
		Shapes traffic to the indicated bit rate according to the algorithm specified.

Step 8	**shape adaptive** *rate-in-bps* **Example:** `Device(config-pmap-c)# shape adaptive 9000`	Shapes traffic to the indicated bit rate according to the algorithm specified.

Customizing Frame Relay for Your Network

Configuring Frame Relay Subinterfaces

Configuring Subinterfaces

Note Multipoint DLCI configurations are currently not supported. Cisco IOS XE software supports point-to-point connections.

To configure subinterfaces on a Frame Relay network, use the following commands beginning in global configuration mode:

SUMMARY STEPS

1. Router(config)# **interface type** *number* **.** *subinterface-number* {**multipoint** | **point-to-point**}
2. Router(config-subif)# **encapsulation frame-relay**

DETAILED STEPS

	Command or Action	Purpose
Step 1	Router(config)# **interface type** *number* **.** *subinterface-number* {**multipoint** | **point-to-point**}	Creates a point-to-point or multipoint subinterface. • Cisco IOS XE software only supports point-to-point subinterfaces.
Step 2	Router(config-subif)# **encapsulation frame-relay**	Configures Frame Relay encapsulation on the serial interface.

Defining Subinterface Addressing on Point-to-Point Subinterfaces

If you specified a point-to-point subinterface in the preceding procedure, use the following command in subinterface configuration mode:

SUMMARY STEPS

1. Router(config-subif)# **frame-relay interface-dlci** *dlci*

DETAILED STEPS

	Command or Action	Purpose
Step 1	Router(config-subif)# **frame-relay interface-dlci** *dlci*	Associates the selected point-to-point subinterface with a DLCI.

Configuring a Backup Interface for a Subinterface

To configure a backup interface for a Frame Relay subinterface, use the following commands beginning in global configuration mode:

SUMMARY STEPS

1. Router(config)# **interface type** *number*
2. Router(config-if)# **encapsulation frame-relay**
3. Router(config)# **interface type** *number* **.** *subinterface-number* **point-to-point**
4. Router(config-subif)# **frame-relay interface-dlci** *dlci*
5. Router(config-subif)# **backup interface type** *number*
6. Router(config-subif)# **backup delay** *enable-delay disable-delay*

DETAILED STEPS

	Command or Action	Purpose
Step 1	Router(config)# **interface type** *number*	Specifies the interface.
Step 2	Router(config-if)# **encapsulation frame-relay**	Configures Frame Relay encapsulation.
Step 3	Router(config)# **interface type** *number* **.** *subinterface-number* **point-to-point**	Configures the subinterface.
Step 4	Router(config-subif)# **frame-relay interface-dlci** *dlci*	Specifies DLCI for the subinterface.
Step 5	Router(config-subif)# **backup interface type** *number*	Configures backup interface for the subinterface.
Step 6	Router(config-subif)# **backup delay** *enable-delay disable-delay*	Specifies backup enable and disable delay.

Disabling or Reenabling Frame Relay Inverse ARP

To select or disable Inverse ARP, use one of the following commands in interface configuration mode:

Command	Purpose
`frame-relay inverse-arp` *`protocol dlci`*	Enables Frame Relay Inverse ARP for a specific protocol and DLCI pair, only if it was previously disabled.
`no frame relay inverse-arp` *`protocol dlci`*	Disables Frame Relay Inverse ARP for a specific protocol and DLCI pair.

Configuring Frame Relay Fragmentation

Configuring End-to-End FRF.12 Fragmentation

To configure FRF.12 fragmentation in a Frame Relay map class, use the following commands beginning in global configuration mode:

SUMMARY STEPS

1. Router(config)# **map-class frame-relay** *map-class-name*
2. Router(config-map-class)# **frame-relay fragment** *fragment_size*

DETAILED STEPS

	Command or Action	Purpose
Step 1	Router(config)# **map-class frame-relay** *map-class-name*	Specifies a map class to define QoS values for a Frame Relay SVC or PVC. The map class can be applied to one or many PVCs.
Step 2	Router(config-map-class)# **frame-relay fragment** *fragment_size*	Configures Frame Relay fragmentation for the map class. The *fragment_size* argument defines the payload size of a fragment; it excludes the Frame Relay headers and any Frame Relay fragmentation header. The valid range is from 16 to 1600 bytes, and the default is 53.

Verifying the Configuration of End-to-End FRF.12 Fragmentation

To verify FRF.12 fragmentation, use one or more of the following EXEC commands:

Command	Purpose
show frame-relay fragment [**interface** *interface*] [*dlci*]	Displays Frame Relay fragmentation information.
show frame-relay pvc [**interface** *interface*] [*dlci*]	Displays statistics about PVCs for Frame Relay interfaces.

Configuring TCP IP Header Compression

Configuring an Individual IP Map for TCP IP Header Compression

To configure an IP map to use Cisco-proprietary encapsulation and TCP/IP header compression, use the following command in interface configuration mode:

Command	Purpose
frame-relay map ip *ip-address dlci* [**broadcast**] **tcp header-compression** [**active** | **passive**] [**connections** *number*]	Configures an IP map to use TCP/IP header compression. Cisco-proprietary encapsulation is enabled by default.

Configuring an Interface for TCP IP Header Compression

To apply TCP/IP header compression to an interface, you must use the following commands in interface configuration mode:

SUMMARY STEPS

1. Router(config-if)# **encapsulation frame-relay**
2. Router(config-if)# **frame-relay ip tcp header-compression** [**passive**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	Router(config-if)# **encapsulation frame-relay**	Configures Cisco-proprietary encapsulation on the interface.
Step 2	Router(config-if)# **frame-relay ip tcp header-compression** [**passive**]	Enables TCP/IP header compression.

Disabling TCP IP Header Compression

You can disable TCP/IP header compression by using either of two commands that have different effects, depending on whether Frame Relay IP maps have been explicitly configured for TCP/IP header compression or have inherited their compression characteristics from the interface.

Frame Relay IP maps that have explicitly configured TCP/IP header compression must also have TCP/IP header compression explicitly disabled.

To disable TCP/IP header compression, use one of the following commands in interface configuration mode:

Command	Purpose
no frame-relay ip tcp header-compression	Disables TCP/IP header compression on all Frame Relay IP maps that are not explicitly configured for TCP header compression.
frame-relay map ip *ip-address dlci* **nocompress**	Disables RTP and TCP/IP header compression on a specified Frame Relay IP map.

Configuring Discard Eligibility

Defining a DE List

To define a DE list specifying the packets that can be dropped when the Frame Relay switch is congested, use the following command in global configuration mode:

SUMMARY STEPS

1. Router(config)# **frame-relay de-list** *list-number* {**protocol** *protocol* | **interface** *type number*} *characteristic*

DETAILED STEPS

	Command or Action	Purpose
Step 1	Router(config)# **frame-relay de-list** *list-number* {**protocol** *protocol* | **interface** *type number*} *characteristic*	Defines a DE list.

Defining a DE Group

To define a DE group specifying the DE list and DLCI affected, use the following command in interface configuration mode:

Command	Purpose
frame-relay de-group *group-number dlci*	Defines a DE group.

Configuring DLCI Priority Levels

To configure DLCI priority levels, use the following command in interface configuration mode:

Command	Purpose
frame-relay priority-dlci-group *group-number high-dlci medium-dlci normal-dlci low-dlci*	Enables multiple parallel DLCIs for different Frame Relay traffic types; associates and sets level of specified DLCIs with same group. **Note** If you do not explicitly specify a DLCI for each of the priority levels, the last DLCI specified in the command line is used as the value of the remaining arguments. At a minimum, you must configure the high-priority and the medium-priority DLCIs.

Monitoring and Maintaining the Frame Relay Connections

To monitor Frame Relay connections, use any of the following commands in EXEC mode:

Command	Purpose
clear frame-relay-inarp	Clears dynamically created Frame Relay maps, which are created by the use of Inverse ARP.
show interfaces serial *type number*	Displays information about Frame Relay DLCIs and the LMI.
show frame-relay lmi [*type number*]	Displays LMI statistics.
show frame-relay map	Displays the current Frame Relay map entries.
show frame-relay pvc [*type number* [*dlci*]]	Displays PVC statistics.
show frame-relay route	Displays configured static routes.
show frame-relay traffic	Displays Frame Relay traffic statistics.
show frame-relay lapf	Displays information about the status of LAPF.
show frame-relay svc maplist	Displays all the SVCs under a specified map list.

Configuration Examples for Frame Relay

Example IETF Encapsulation

Example IETF Encapsulation on the Interface

The following example sets IETF encapsulation at the interface level. The keyword **ietf** sets the default encapsulation method for all maps to IETF.

```
encapsulation frame-relay ietf
frame-relay map ip 131.108.123.2 48 broadcast
frame-relay map ip 131.108.123.3 49 broadcast
```

Example IETF Encapsulation on a Per-DLCI Basis

The following example configures IETF encapsulation on a per-DLCI basis. This configuration has the same result as the configuration in the first example.

```
encapsulation frame-relay
frame-relay map ip 131.108.123.2 48 broadcast ietf
frame-relay map ip 131.108.123.3 49 broadcast ietf
```

Example Static Address Mapping

Example Two Routers in Static Mode

The following example shows how to configure two routers for static mode:

Configuration for Router 1

```
interface serial0
 ip address 131.108.64.2 255.255.255.0
 encapsulation frame-relay
 keepalive 10
 frame-relay map ip 131.108.64.1 43
```

Configuration for Router 2

```
interface serial1
 ip address 131.108.64.1 255.255.255.0
 encapsulation frame-relay
 keepalive 10
 frame-relay map ip 131.108.64.2 43
```

Example Subinterface

Example Basic Subinterface

In the following example, subinterface 1 is configured as a point-to-point subnet and subinterface 2 is configured as a multipoint subnet.

```
interface serial 0
 encapsulation frame-relay
interface serial 0.1 point-to-point
 ip address 10.0.1.1 255.255.255.0
 frame-relay interface-dlci 42
!
interface serial 0.2 multipoint
 ip address 10.0.2.1 255.255.255.0
 frame-relay map ip 10.0.2.2 18
```

Example Frame Relay Traffic Shaping

Example Configuring Class-Based Weighted Fair Queueing

The following example provides a sample configuration for Class-Based Weighted Fair Queueing (CBWFQ) with FRTS:

```
class-map voice
 match ip dscp ef
policy-map llq
 class voice
  priority 32
policy-map shape-policy-map
 class class-default
  shape average 64000
  shape adaptive 32000
  service-policy llq
map-class frame-relay shape-map-class

service-policy output shape-policy-map
interface serial 0/0
encapsulation frame-relay
interface serial 0/0.1 point-to-point
ip address 192.168.1.1 255.255.255.0
frame-relay interface-dlci 100
class shape-map-class
```

Example Configuring Class-Based Weighted Fair Queueing with Fragmentation

The following example provides a sample configuration for CBWFQ and fragmentation with FRTS. This configuration example is exactly the same as the example shown in the Example Configuring Class-Based Weighted Fair Queueing section, with the addition of the **frame-relay fragment** command to configure fragmentation.

```
class-map voice
 match ip dscp ef
policy-map llq
 class voice
  priority 32
policy-map shape-policy-map
 class class-default
  shape average 64000
  shape adaptive 32000
  service-policy llq
map-class frame-relay shape-map-class
 frame-relay fragment 80
 service-policy output shape-policy-map
interface serial 0/0
 encapsulation frame-relay
interface serial 0/0.1 point-to-point
 ip address 192.168.1.1 255.255.255.0
 frame-relay interface-dlci 100
  class shape-map-class
```

Example Backward Compatibility

The following configuration provides backward compatibility and interoperability with versions not compliant with RFC 1490. The **ietf** keyword is used to generate RFC 1490 traffic. This configuration is possible because of the flexibility provided by separately defining each map entry.

```
encapsulation frame-relay
frame-relay map ip 131.108.123.2 48 broadcast ietf
! interoperability is provided by IETF encapsulation
frame-relay map ip 131.108.123.3 49 broadcast ietf
frame-relay map ip 131.108.123.7 58 broadcast
! this line allows the router to connect with a
! device running an older version of software
frame-relay map decnet 21.7 49 broadcast
```

Example Booting from a Network Server over Frame Relay

When booting from a TFTP server over Frame Relay, you cannot boot from a network server via a broadcast. You must boot from a specific TFTP host. Also, a **frame-relay map** command must exist for the host from which you will boot.

For example, if file "gs3-bfx" is to be booted from a host with IP address 131.108.126.2, the following commands would need to be in the configuration:

```
boot system gs3-bfx 131.108.126.2
!
interface Serial 0
 encapsulation frame-relay
 frame-relay map IP 131.108.126.2 100 broadcast
```

The **frame-relay map** command is used to map an IP address into a DLCI address. To boot over Frame Relay, you must explicitly give the address of the network server to boot from, and a **frame-relay map** entry must exist for that site. For example, if file "gs3-bfx.83-2.0" is to be booted from a host with IP address 131.108.126.111, the following commands must be in the configuration:

```
boot system gs3-bfx.83-2.0 131.108.13.111
!
interface Serial 1
 ip address 131.108.126.200 255.255.255.0
 encapsulation frame-relay
 frame-relay map ip 131.108.126.111 100 broadcast
```

In this case, 100 is the DLCI that can get to host 131.108.126.111.

The remote router must be configured with the following command:

```
frame-relay map ip 131.108.126.200 101 broadcast
```

This entry allows the remote router to return a boot image (from the network server) to the router booting over Frame Relay. Here, 101 is a DLCI of the router being booted.

Example Frame Relay Fragmentation Configuration

Example FRF.12 Fragmentation

The following example shows the configuration of pure end-to-end FRF.12 fragmentation and weighted fair queueing in the map class called "frag". The fragment payload size is set to 40 bytes. The "frag" map class is associated with DLCI 100 on serial interface 1.

```
router(config)#
interface serial 1

router(config-if)# frame-relay interface-dlci 100
router(config-fr-dlci)# class frag
router(config-fr-dlci)# exit
router(config)# map-class frame-relay frag
router(config-map-class)# frame-relay fragment 40
```

Example TCP IP Header Compression

Example IP Map with Inherited TCP IP Header Compression

Note Shut down the interface or subinterface prior to adding or changing compression techniques. Although shutdown is not required, shutting down the interface ensures that it is reset for the new data structures.

The following example shows an interface configured for TCP/IP header compression and an IP map that inherits the compression characteristics. Note that the Frame Relay IP map is not explicitly configured for header compression.

```
interface serial 1
 encapsulation frame-relay
 ip address 131.108.177.178 255.255.255.0
 frame-relay map ip 131.108.177.177 177 broadcast
 frame-relay ip tcp header-compression passive
```

Use of the **show frame-relay map** command will display the resulting compression and encapsulation characteristics; the IP map has inherited passive TCP/IP header compression:

```
Router> show frame-relay map
Serial 1   (administratively down): ip 131.108.177.177
           dlci 177 (0xB1,0x2C10), static,
           broadcast,
           CISCO
           TCP/IP Header Compression (inherited), passive (inherited)
```

This example also applies to dynamic mappings achieved with the use of Inverse ARP on point-to-point subinterfaces where no Frame Relay maps are configured.

Example Using an IP Map to Override TCP IP Header Compression

The following example shows the use of a Frame Relay IP map to override the compression set on the interface:

```
interface serial 1
 encapsulation frame-relay
 ip address 131.108.177.178 255.255.255.0
 frame-relay map ip 131.108.177.177 177 broadcast nocompress
 frame-relay ip tcp header-compression passive
```

Use of the **show frame-relay map** command will display the resulting compression and encapsulation characteristics; the IP map has not inherited TCP header compression:

```
Router> show frame-relay map
Serial 1   (administratively down): ip 131.108.177.177
           dlci 177 (0xB1,0x2C10), static,
           broadcast,
           CISCO
```

Example Disabling Inherited TCP IP Header Compression

In this example, following is the initial configuration:

```
interface serial 1
 encapsulation frame-relay
 ip address 131.108.177.179 255.255.255.0
 frame-relay ip tcp header-compression passive
 frame-relay map ip 131.108.177.177 177 broadcast
 frame-relay map ip 131.108.177.178 178 broadcast tcp header-compression
```

Enter the following commands to enable inherited TCP/IP header compression:

```
serial interface 1
 no frame-relay ip tcp header-compression
```

Use of the **show frame-relay map** command will display the resulting compression and encapsulation characteristics:

```
Router> show frame-relay map
Serial 1   (administratively down): ip 131.108.177.177 177
           dlci 177(0xB1, 0x2C10), static,
           broadcast
           CISCO
Serial 1   (administratively down): ip 131.108.177.178 178
           dlci 178(0xB2,0x2C20), static
           broadcast
           CISCO
           TCP/IP Header Compression (enabled)
```

As a result, header compression is disabled for the first map (with DLCI 177), which inherited its header compression characteristics from the interface. However, header compression is not disabled for the second map (DLCI 178), which is explicitly configured for header compression.

Example Disabling Explicit TCP IP Header Compression

In this example, the initial configuration is the same as in the preceding example, but you must enter the following set of commands to enable explicit TCP/IP header compression:

```
serial interface 1
 no frame-relay ip tcp header-compression
 frame-relay map ip 131.108.177.178 178 nocompress
```

Use of the **show frame-relay map** command will display the resulting compression and encapsulation characteristics:

```
Router> show frame-relay map
Serial 1   (administratively down): ip 131.108.177.177 177
           dlci 177(0xB1,0x2C10), static,
           broadcast
           CISCO
Serial 1   (administratively down): ip 131.108.177.178 178
```

```
dlci 178(0xB2,0x2C20), static
broadcast
CISCO
```

The result of the commands is to disable header compression for the first map (with DLCI 177), which inherited its header compression characteristics from the interface, and also explicitly to disable header compression for the second map (with DLCI 178), which was explicitly configured for header compression.

Additional References

Related Documents

Related Topic	Document Title
Cisco IOS XE Wide-Area Networking configuration tasks	*Cisco IOS XE Wide-Area Networking Configuration Guide*, Release 2
Wide-Area networking commands	*Cisco IOS Wide-Area Networking Command Reference*

Standards

Standard	Title
None	--

MIBs

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

RFCs

RFC	Title
None	--

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/techsupport

Feature Information for Configuring Frame Relay

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 Configuring Frame Relay

Feature Name	Releases	Feature Information
Frame Relay	Cisco IOS XE Release 2.1	Frame Relay is a high-performance WAN protocol that operates at the physical and data link layers.
Frame Relay Encapsulation	Cisco IOS XE Release 2.1	Frame Relay supports encapsulation of all supported protocols in conformance with RFC 1490, allowing interoperability between multiple vendors.
Frame Relay Fragmentation (FRF.12)	Cisco IOS XE Release 2.1	End-to-end FRF.12 fragmentation supports real-time and non-real-time data packets on lower-speed links without causing excessive delay to the real-time data. FRF.12 fragmentation is defined by the FRF.12 Implementation Agreement.
Local Management Interface	Cisco IOS XE Release 2.1	Local Management Interface (LMI) autosense enables an interface to determine the LMI type supported by a switch. With the support for LMI autosense, you do not need to configure the LMI explicitly.