CHAPTER 23

Configuring IPsec VPN Fragmentation and MTU

This chapter provides information about configuring IPsec VPN fragmentation and the maximum transmission unit (MTU). It includes the following sections:

- Understanding IPsec VPN Fragmentation and MTU, page 23-1
- Configuring IPsec Prefragmentation, page 23-16
- Configuring MTU Settings, page 23-18
- Configuration Examples, page 23-20

For more information about the commands used in this chapter, see the *Catalyst 6500 Series Cisco IOS Command Reference, Release 12.2SX* publication. Also refer to the related Cisco IOS Release 12.2 software command reference and master index publications. For more information about accessing these publications, see the "Related Documentation" section on page xlv.

Understanding IPsec VPN Fragmentation and MTU

This section includes the following topics:

- Overview of Fragmentation and MTU, page 23-1
- IPsec Prefragmentation, page 23-3
- Fragmentation in Cisco IOS Release 12.2(33)SXH and Earlier Releases, page 23-3
- Fragmentation in Cisco IOS Release 12.2(33)SXI and Later Releases, page 23-10

Overview of Fragmentation and MTU

When a packet is nearly the size of the maximum transmission unit (MTU) of the physical egress port of the encrypting switch, and it is encapsulated with IPsec headers, it probably will exceed the MTU of the egress port. This condition causes the packet to be fragmented after encryption (post-fragmentation), which requires the IPsec peer to perform reassembly before decryption, degrading its performance. To minimize post-fragmentation, you can set the MTU in the upstream data path to ensure that most fragmentation occurs before encryption (prefragmentation). Prefragmentation for IPsec VPNs avoids performance degradation by shifting the reassembly task from the receiving IPsec peer to the receiving end hosts.

Note In this document, prefragmentation refers to fragmentation prior to any type of encapsulation, such as IPsec or GRE. IPsec prefragmentation refers to fragmentation prior to IPsec encryption.

To ensure prefragmentation in most cases, we recommend the following MTU settings:

- The crypto interface VLAN MTU associated with the IPsec VPN SPA should be set to be equal or less than the egress interface MTU.
- For GRE over IPsec, the IP MTU of the GRE tunnel interface should be set below the egress interface MTU by at least the overhead of IPsec encryption and the 24-byte GRE+IP header (20-byte IP header plus 4-byte GRE header). Because options such as tunnel key (RFC 2890) are not supported, the GRE+IP IP header will always be 24 bytes.

Note The crypto interface VLAN MTU, the egress interface MTU, and the IP MTU of the GRE tunnel interface are all Layer 3 parameters.

The following are additional guidelines for IPsec prefragmentation and MTU in crypto-connect mode:

- If a packet's DF (Don't Fragment) bit is set and the packet exceeds the MTU at any point in the data path, the packet will be dropped. To prevent a packet drop, clear the DF bit by using either policy-based routing (PBR) or the **crypto df-bit clear** command.
- In Cisco IOS Release 12(33)SXH, and earlier releases, the IPsec VPN SPA does not support path MTU discovery (PMTUD) on GRE tunnels using the **tunnel path-mtu-discovery** command. In Cisco IOS Release 12(33)SXI and later releases, PMTUD is supported on GRE tunnels.
- If GRE encapsulation is not taken over by the IPsec VPN SPA, and if the packets exceed the IP MTU of the GRE tunnel interface, the route processor will fragment and encapsulate the packets.

Note If the supervisor engine performs GRE encapsulation, the encapsulated packets will have the DF bit set.

The IPsec and GRE prefragmentation feature differs based on the Cisco IOS release, as described in Table 23-1.

Table 23-1 IPsec and GRE Prefragmentation based on Cisco IOS Release

Cisco IOS Release	Prefragmentation Feature
12.2(18)SXE	A single prefragmentation process occurs for both IPsec and GRE, based on the smaller of the IP MTU and the egress interface MTU. To prevent fragmentation or packet loss, configure the VLAN MTU as the largest predicted GRE packet size (IP length plus GRE overhead), and the egress interface MTU as the largest predicted GRE/IPsec packet size (IP length plus GRE overhead plus IPsec overhead).
12.2(18)SXF	GRE fragmentation and IPsec fragmentation are separate processes. If GRE encapsulation is performed by the IPsec VPN SPA, prefragmentation of outbound packets will be based on the IP MTU of the tunnel interface. After GRE encapsulation is performed by the IPsec VPN SPA, depending on the IPsec prefragmentation settings, further fragmentation may occur. The IPsec fragmentation behavior is unchanged from Cisco IOS Release 12.2(18)SXE, and is based on the IPsec MTU configuration of the egress interface.

Table 23-1 IPsec and GRE Prefragmentation based on Cisco IOS Release (continued)

12.2SXH	Path MTU discovery (PMTUD) is supported in crypto-connect mode.
12.2SXI and later	• Prefragmentation for IPsec is based on the IP MTU of the tunnel or the crypto interface VLAN, not the egress interface. • The IPsec VPN SPA will perform only prefragmentation or postfragmentation, but not both (although the RP may also perform fragmentation). • Postfragmentation of tunnel interfaces is not supported. • PMTUD is supported in crypto-connect and VRF modes. • The **ip tcp adjust-mss** command is supported in crypto-connect and VRF modes on GRE, GRE/TP, and sVTI tunnels.

For general information on fragmentation and MTU issues, see "Resolve IP Fragmentation, MTU, MSS, and PMTUD Issues with GRE and IPsec" at this URL:

http://www.cisco.com/en/US/tech/tk827/tk369/technologies_white_paper09186a00800d6979.shtml

IPsec Prefragmentation

In the IPsec prefragmentation process (also called Look-Ahead Fragmentation, or LAF), the encrypting switch can predetermine the encapsulated packet size from information available in transform sets, which are configured as part of the IPsec security association (SA). IPsec prefragmentation avoids reassembly by the receiving switch before decryption and helps improve overall IPsec traffic throughput by shifting the reassembly task to the end hosts.

A packet will be fragmented before encryption in the following situations:

- (in Cisco IOS Release 12.2(33)SXH and earlier releases) if it is predetermined that the encrypted packet will exceed the MTU of the output interface.
- (in Cisco IOS Release 12.2(33)SXI and later releases) if either of the following conditions is met:
  - the encrypted packet will exceed the MTU of the crypto interface VLAN
  - the clear packet exceeds the tunnel MTU.

Fragmentation in Cisco IOS Release 12.2(33)SXH and Earlier Releases

The fragmentation process differs depending on the IPsec VPN mode and whether GRE or VTI are used, as described in the following sections:

- Fragmentation in Crypto-Connect Mode, page 23-4
- Fragmentation of IPsec (Using Crypto Maps) Packets in VRF Mode, page 23-5
- Fragmentation of GRE Packets with Tunnel Protection in VRF Mode, page 23-7
- Fragmentation in VTIs, page 23-8

In the following fragmentation descriptions, we assume that the DF (Don't Fragment) bit is not set for packets entering the flowchart. If a packet requires fragmentation and the DF bit is set, the packet will be dropped.

Fragmentation in Crypto-Connect Mode

The following are the relevant MTU settings for fragmentation of packets in crypto-connect mode:

- The MTU of the interface VLAN.

  Prefragmentation of non-GRE traffic by the RP will be based on this MTU.
- The IP MTU of the GRE tunnel.

  Prefragmentation of GRE traffic will be based on this MTU.
- The MTU of the physical egress interface.

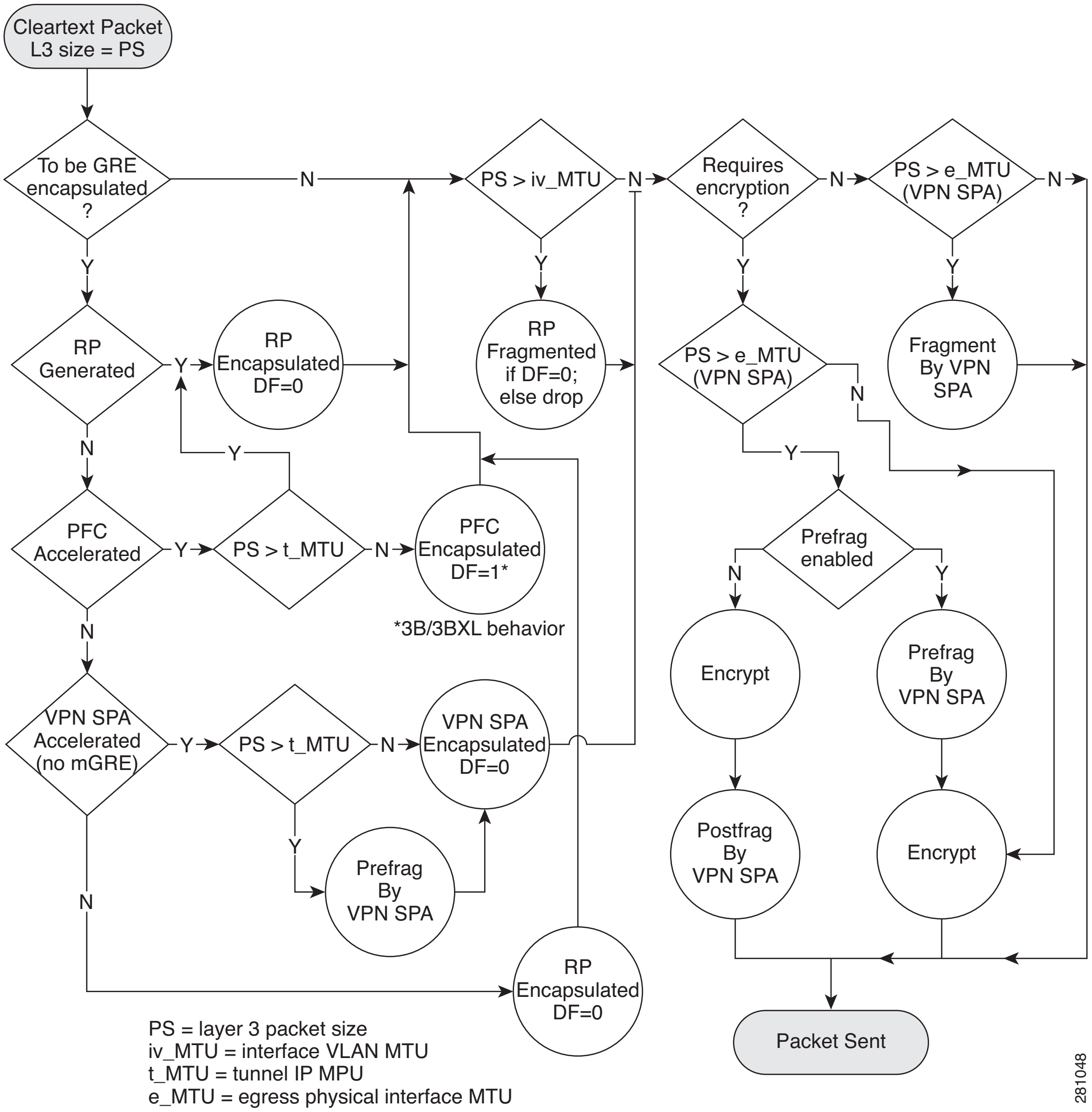
  Pre- and post-fragmentation by the IPsec VPN SPA will be based on this MTU.

Fragmentation will be performed as follows:

- If any packets to be sent to the IPsec VPN SPA exceed the MTU of the interface VLAN, the RP will perform prefragmentation before sending the packets to the IPsec VPN SPA.
- If packets to be GRE encapsulated exceed the IP MTU of the GRE tunnel:
  - The RP will perform prefragmentation when the tunnel is not taken over by the IPsec VPN SPA.
  - The IPsec VPN SPA will perform prefragmentation when the tunnel is taken over by the IPsec VPN SPA.
- If packets to be encrypted will exceed the MTU of the physical egress interface:
  - If IPsec prefragmentation is enabled, the IPsec VPN SPA will perform prefragmentation of the packets. The IPsec VPN SPA will not perform post-fragmentation.
  - If IPsec prefragmentation is disabled, the IPsec VPN SPA will perform post-fragmentation of the encrypted packets. The IPsec VPN SPA will not perform prefragmentation.
- If unencrypted egress packets will exceed the MTU of the physical egress interface, the IPsec VPN SPA will perform fragmentation of the packets.

Figure 23-1 shows the fragmentation process for packets in crypto-connect mode.

Figure 23-1 Fragmentation of Packets in Crypto-Connect Mode



Fragmentation of IPsec (Using Crypto Maps) Packets in VRF Mode

The following are the relevant MTU settings for fragmentation of IPsec traffic in VRF mode:

- The MTU of the interface VLAN.

  Prefragmentation by the RP will be based on this MTU.

- The MTU of the physical egress interface.

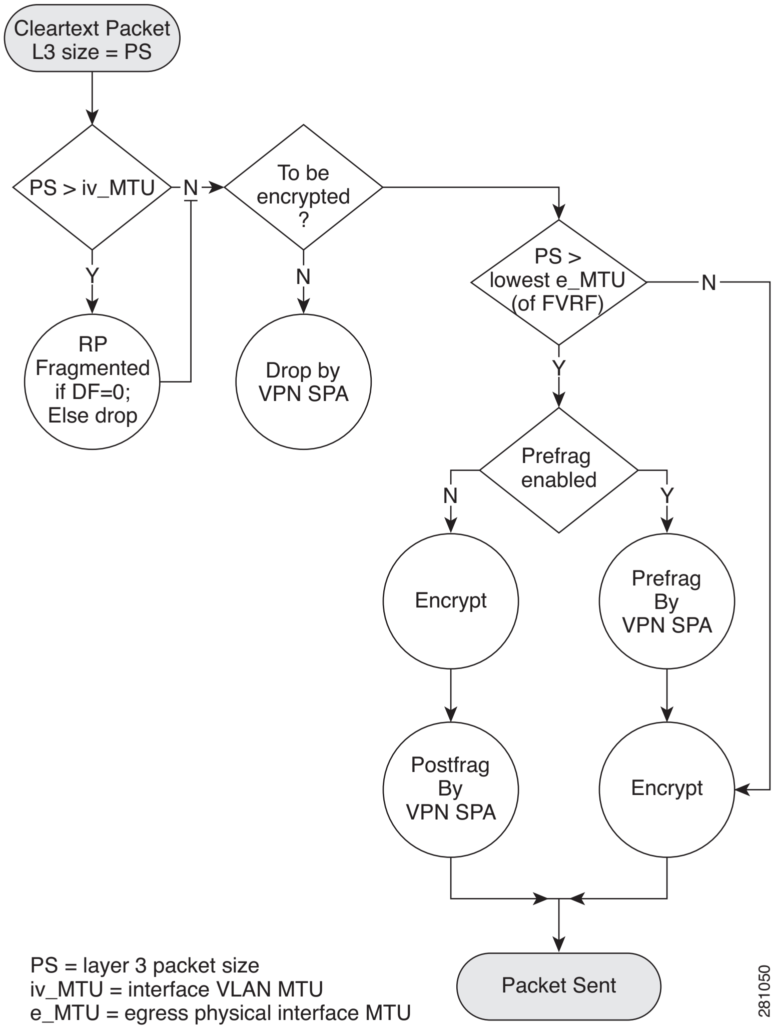
  Pre- and post-fragmentation by the IPsec VPN SPA will be based on this MTU.

Fragmentation will be performed as follows:

- If packets exceed the MTU of the interface VLAN, the RP will perform prefragmentation.
- If encrypted egress packets will exceed the lowest MTU of any physical egress interface on the FVRF:
  - If IPsec prefragmentation is enabled, the IPsec VPN SPA will perform prefragmentation of the packets. The IPsec VPN SPA will not perform post-fragmentation.
  - If IPsec prefragmentation is disabled, the IPsec VPN SPA will perform post-fragmentation of the encrypted packets. The IPsec VPN SPA will not perform prefragmentation.

The fragmentation process for IPsec packets in VRF mode is shown in Figure 23-2.

Figure 23-2 Fragmentation of IPsec Packets in VRF Mode



Fragmentation of GRE Packets with Tunnel Protection in VRF Mode

The following are the relevant MTU settings for fragmentation of GRE traffic with tunnel protection in VRF mode:

- The IP MTU of the GRE tunnel.

  Prefragmentation will be based on this MTU.
- The lowest MTU of any physical egress interface on the FVRF.

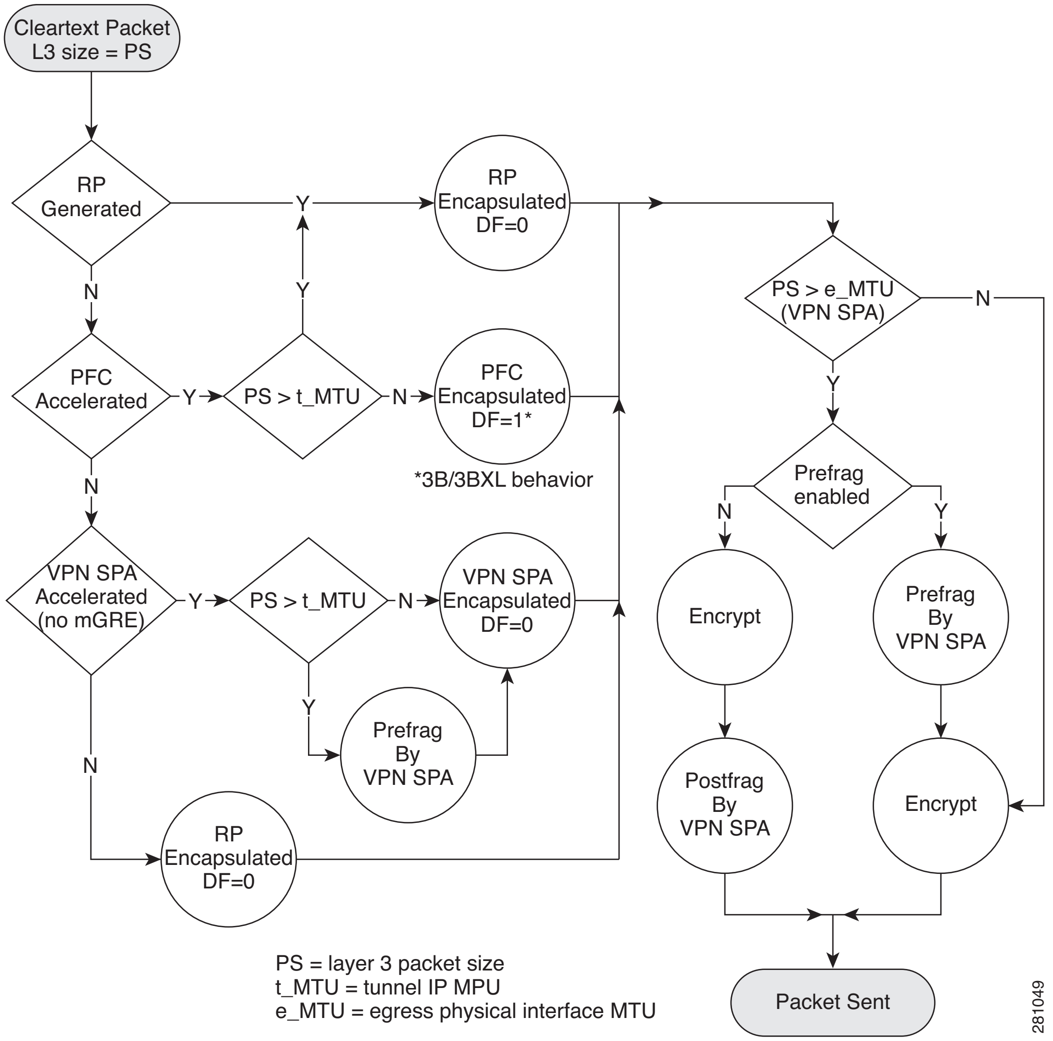
  Pre- and post-fragmentation by the IPsec VPN SPA will be based on this MTU.

Fragmentation will be performed as follows:

- If packets to be encapsulated exceed the IP MTU of the GRE tunnel:
  - The RP will perform prefragmentation when the tunnel is not taken over by the IPsec VPN SPA.
  - The IPsec VPN SPA will perform prefragmentation when the tunnel is taken over by the IPsec VPN SPA.
- If encrypted GRE-encapsulated packets will exceed the lowest MTU of any physical egress interface on the FVRF:
  - If IPsec prefragmentation is enabled, the IPsec VPN SPA will perform prefragmentation of the GRE-encapsulated packets. The IPsec VPN SPA will not perform post-fragmentation.
  - If IPsec prefragmentation is disabled, the IPsec VPN SPA will perform post-fragmentation of the encrypted GRE-encapsulated packets. The IPsec VPN SPA will not perform prefragmentation.

The fragmentation process for GRE packets with tunnel protection in VRF mode is shown in Figure 23-3.

Figure 23-3 Fragmentation of GRE Packets with Tunnel Protection in VRF Mode



Fragmentation in VTIs

The following are the relevant MTU settings for fragmentation of VTI packets:

- The IP MTU of the VTI tunnel interface.

  Prefragmentation will be based on this MTU.

Note We recommend that the IP MTU of the VTI tunnel interface be left at its default value. If you change it, be sure that it does not exceed the MTU of the physical egress interface minus the IPsec overhead.

- The MTU of the physical egress interface.

  Post-fragmentation by the IPsec VPN SPA will be based on this MTU.

Fragmentation will be performed as follows:

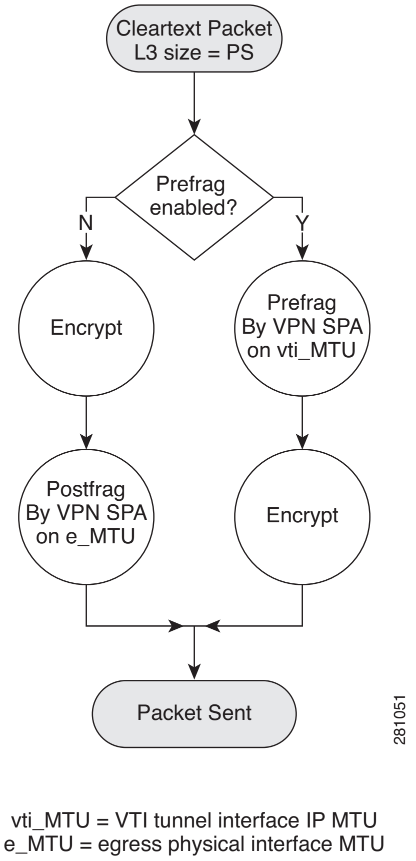
- If IPsec prefragmentation is enabled, the IPsec VPN SPA will perform prefragmentation of packets that exceed the IP MTU of the VTI tunnel interface. The IPsec VPN SPA will not perform post-fragmentation.

Note The RP will perform post-fragmentation of packets that exceed the MTU of the egress interface. This is considered a misconfiguration.

- If IPsec prefragmentation is disabled, the IPsec VPN SPA will perform post-fragmentation of packets that exceed the MTU of the egress interface. The IPsec VPN SPA will not perform prefragmentation.

The fragmentation process for VTI packets is shown in Figure 23-4.

Figure 23-4 Fragmentation of VTI Packets


Cleartext Packet
L3 size = PS
Prefrag enabled?
N
Y
Encrypt
Prefrag By VPN SPA on vti_MTU
Postfrag By VPN SPA on e_MTU
Encrypt
Packet Sent
281051
vti_MTU = VTI tunnel interface IP MTU
e_MTU = egress physical interface MTU

Fragmentation in Cisco IOS Release 12.2(33)SXI and Later Releases

The fragmentation in Cisco IOS Release 12.2(33)SXI and later releases differs from earlier fragmentation in these significant ways:

- The IPsec VPN SPA will perform only a single fragmentation operation, either prefragmentation or postfragmentation, but not both.
- Fragmentation is based on the IP MTU of the tunnel or of the crypto interface VLAN, not the egress interface.
- Path MTU discovery (PMTUD) is supported in both crypto-connect and VRF modes.
- The **ip tcp adjust-mss** command is supported in all modes.

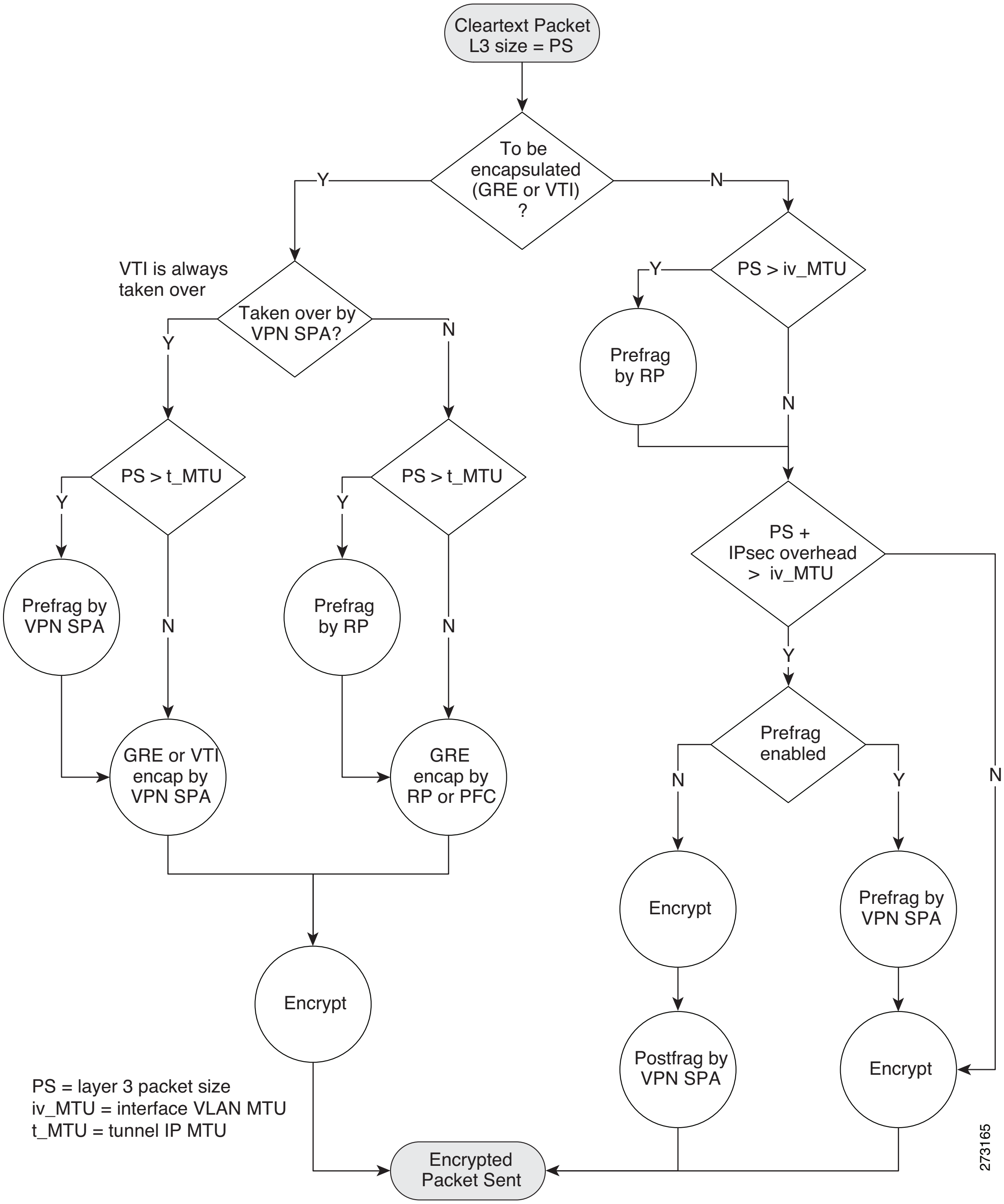
As in earlier releases, the fragmentation process differs depending on the IPsec VPN mode and whether GRE or VTI is used. The process is described in the following sections:

- Overview of the Fragmentation Process, page 23-11
- Fragmentation of IPsec Packets in Crypto-Connect Mode, page 23-12
- Fragmentation of GRE Packets in Crypto-Connect Mode, page 23-13
- Fragmentation of IPsec Packets in VRF Mode, page 23-14
- Fragmentation of GRE Packets in VRF Mode, page 23-14
- Fragmentation of IPsec Packets Using VTI, page 23-15

Overview of the Fragmentation Process

Figure 23-5 shows the fragmentation process for IPsec packets in all VPN modes.

Figure 23-5 Fragmentation of IPsec Packets in All VPN Modes



These notes apply to the fragmentation process described in Figure 23-5:

- The fragmentation process applies only when the DF (Don't Fragment) bit is not set for cleartext packets entering the flowchart. If a packet requires fragmentation and the DF bit is set, the packet will be dropped.
- VTI encapsulation is always taken over by the IPsec VPN SPA.
- GRE encapsulation of RP-generated packets is never taken over by the IPsec VPN SPA.
- GRE encapsulation of mGRE packets is never taken over by the IPsec VPN SPA.

Fragmentation of IPsec Packets in Crypto-Connect Mode

For fragmentation of packets in crypto-connect mode, the following are the MTU setting requirements and recommendations:

- The configured IP MTU of the interface VLAN
  - Prefragmentation of traffic by the IPsec VPN SPA is based on this MTU.
  - You must configure this MTU to be less than or equal to the minimum MTU of the physical egress interfaces configured on the port VLAN, or packets will be dropped.
- The configured MTU of the LAN interface
  - To avoid fragmentation by the RP, we recommend that you configure the MTU of the LAN interface to be less than or equal to the configured IP MTU of the interface VLAN.

In the following example, a 1500-byte cleartext packet will not be fragmented by the RP, because it is within the MTU of the interface VLAN. The cleartext packet will be fragmented by the IPsec VPN SPA, because the IPsec overhead would cause the encrypted packet to exceed the MTU of the interface VLAN.

A 1600-byte cleartext packet will first be fragmented by the RP, because the packet exceeds the MTU of the interface VLAN. The packet will then be fragmented again by the IPsec VPN SPA, because the IPsec overhead added by the encryption process would cause the encrypted packet to exceed the MTU of the interface VLAN.

```
interface GigabitEthernet1/1
  ! switch inside port
  mtu 9216
  ip address 13.0.0.1 255.255.255.0
!
interface GigabitEthernet1/2
  ! switch outside port
  ! mtu 1500 by default
  switchport
  switchport access vlan 502
  switchport mode access
!
interface Vlan2
  ! interface vlan
  ! mtu 1500 by default
  ip address 11.0.0.2 255.255.255.0
  crypto map testtag
  crypto engine slot 4/0
!
interface Vlan502
  ! port vlan
  no ip address
  crypto connect vlan 2
!
```

Fragmentation of GRE Packets in Crypto-Connect Mode

For fragmentation of packets in crypto-connect mode, the following are the MTU setting requirements and recommendations:

- The configured IP MTU of the crypto interface VLAN
  - You must configure this MTU to be less than or equal to the minimum MTU of the physical egress interfaces configured on the port VLAN, or packets will be dropped.
- The configured MTU of the LAN interface
  - To avoid fragmentation by the RP, we recommend that you configure the MTU of the LAN interface to be less than or equal to the configured IP MTU of the crypto interface VLAN.
- The configured IP MTU of the GRE tunnel interface
  - Prefragmentation of traffic by the IPsec VPN SPA is based on this MTU.
  - You must set this MTU so that IPsec-encrypted GRE packets will not exceed the IP MTU of the crypto interface VLAN, or packets will be dropped. This requirement applies regardless of whether the GRE tunnel is taken over by the IPsec VPN SPA.

In the following example, if the tunnel is taken over by the IPsec VPN SPA, a 1600-byte cleartext packet will be fragmented by the IPsec VPN SPA, because the packet exceeds the IP MTU of the tunnel interface. The fragmented packet will then be GRE-encapsulated and IPsec-encrypted by the IPsec VPN SPA.

If the tunnel is not taken over by the IPsec VPN SPA, a 1600-byte cleartext packet will be fragmented by the RP, because the packet exceeds the IP MTU of the tunnel interface. The fragmented packet will then be GRE-encapsulated by the PFC and IPsec-encrypted by the IPsec VPN SPA.

```
interface Tunnel1
  ip mtu 1400
  ip address 1.0.0.1 255.255.255.0
  tunnel source Vlan2
  tunnel destination 11.0.0.2
!
interface GigabitEthernet1/1
  ! switch inside port
  mtu 9216
  ip address 12.0.0.1 255.255.255.0
!
interface GigabitEthernet1/2
  ! switch outside port
  ! mtu 1500 by default
  switchport
  switchport access vlan 502
  switchport mode access
!
interface Vlan2
  ! mtu 1500 by default
  ip address 11.0.0.1 255.255.255.0
  no mop enabled
  crypto map testtag
  crypto engine slot 4/0
!
interface Vlan502
  no ip address
  crypto connect vlan 2
!
```

Fragmentation of IPsec Packets in VRF Mode

For fragmentation of packets in VRF mode, the following are the MTU setting requirements and recommendations:

- The MTU of the crypto interface VLAN.
  - Prefragmentation by the IPsec VPN SPA will be based on this MTU.
  - You must configure this MTU to be less than or equal to the minimum MTU of the physical egress interfaces, or packets will be dropped.
- The configured MTU of the LAN interface
  - To avoid fragmentation by the RP, we recommend that you configure the MTU of the LAN interface to be less than or equal to the configured IP MTU of the crypto interface VLAN.

In the following example, a 1500-byte cleartext packet will not be fragmented by the RP, because it is within the MTU of the interface VLAN. The cleartext packet will be fragmented by the IPsec VPN SPA, because the IPsec overhead would cause the encrypted packet to exceed the MTU of the interface VLAN.

A 1600-byte cleartext packet will first be fragmented by the RP, because the packet exceeds the MTU of the interface VLAN. The packet will then be fragmented again by the IPsec VPN SPA, because the IPsec overhead added by the encryption process would cause the encrypted packet to exceed the MTU of the interface VLAN.

```
interface GigabitEthernet1/1
  ! switch inside port
  mtu 9216
  ip vrf forwarding ivrf
  ip address 12.0.0.1 255.255.255.0
!
!
interface GigabitEthernet1/2
  ! switch outside port
  ! mtu 1500 by default
  ip address 11.0.0.1 255.255.255.0
  crypto engine slot 4/0 outside
!
interface Vlan2
  ! mtu 1500 by default
  ip vrf forwarding ivrf
  ip address 13.0.0.252 255.255.255.0
  crypto map testtag
  crypto engine slot 4/0 inside
!
```

Fragmentation of GRE Packets in VRF Mode

For fragmentation of packets in VRF mode, the following are the MTU setting requirements and recommendations:

- The MTU of the crypto interface VLAN.
  - You must configure this MTU to be less than or equal to the minimum MTU of the physical egress interfaces configured on the port VLAN, or packets will be dropped.
- The configured MTU of the LAN interface
  - To avoid fragmentation by the RP, we recommend that you configure the MTU of the LAN interface to be less than or equal to the configured IP MTU of the crypto interface VLAN.
- The configured IP MTU of the GRE tunnel interface

  - Prefragmentation by the IPsec VPN SPA will be based on this MTU.
  - You must set this MTU so that IPsec-encrypted GRE packets will not exceed the minimum MTU of the physical egress interfaces, or packets will be dropped. This requirement applies regardless of whether the GRE tunnel is taken over by the IPsec VPN SPA.

In the following example, if the tunnel is taken over by the IPsec VPN SPA, a 1600-byte cleartext packet will be fragmented by the IPsec VPN SPA, because the packet exceeds the IP MTU of the tunnel interface. The fragmented packet will then be GRE-encapsulated and IPsec-encrypted by the IPsec VPN SPA.

If the tunnel is not taken over by the IPsec VPN SPA, a 1600-byte cleartext packet will be fragmented by the RP, because the packet exceeds the IP MTU of the tunnel interface. The fragmented packet will then be GRE-encapsulated by the PFC and IPsec-encrypted by the IPsec VPN SPA.

```
interface Tunnel1
  ip mtu 1400
  ip vrf forwarding coke
  ip address 10.1.1.254 255.255.255.0
  tunnel source 172.1.1.1
  tunnel destination 100.1.1.1
  tunnel protection ipsec profile tp
  crypto engine slot 4/0 inside
!
interface GigabitEthernet6/1
  ! switch outside port
  ! mtu 1500 by default
  ip address 172.1.1.1 255.255.255.0
  crypto engine slot 4/0 outside
!
interface FastEthernet7/13
  ! switch inside port
  mtu 9216
  ip vrf forwarding coke
  ip address 13.1.1.2 255.255.255.0
!
```

Fragmentation of IPsec Packets Using VTI

The following are the relevant MTU settings for fragmentation of sVTI packets:

- The IP MTU of the VTI tunnel interface.
  - Prefragmentation by the IPsec VPN SPA will be based on this MTU.
  - Configuring this MTU is unnecessary because it is automatically adjusted to accommodate the IPsec overhead.

Note We recommend that the IP MTU of the VTI tunnel interface be left at its default value. If you change it, be sure that it does not exceed the MTU of the physical egress interface minus the IPsec overhead.

The fragmentation behavior using VTI is the same as the behavior shown in the "Fragmentation of GRE Packets in VRF Mode" section on page 23-14 for the case in which the tunnel is taken over by the IPsec VPN SPA.

Configuring IPsec Prefragmentation

IPsec prefragmentation can be configured globally or at the interface level. By default, IPsec prefragmentation is enabled globally. Enabling or disabling IPsec prefragmentation at the interface will override the global configuration.

IPsec Prefragmentation Configuration Guidelines

Note In Cisco IOS Release 12.2(33)SXI and later releases, tunnels support only IPsec prefragmentation; postfragmentation is not supported. The guidelines in this section apply only to an interface to which a crypto map is applied.

When configuring IPsec prefragmentation, follow these guidelines:

- To configure IPsec prefragmentation at the interface level, apply it on the interface to which the crypto map is applied.
- If an IPsec peer is experiencing high CPU utilization with large packet flows, verify that IPsec prefragmentation is enabled (the peer may be reassembling large packets).
- IPsec prefragmentation for IPsec VPNs operates in IPsec tunnel mode. It does not apply in IPsec transport mode.
- IPsec prefragmentation for IPsec VPNs functionality depends on the **crypto ipsec df-bit** configuration of the interface to which the crypto map is applied, and on the incoming packet “do not fragment” (DF) bit state. For general information about IPsec prefragmentation, see the following URL:

  http://www.cisco.com/en/US/docs/ios/12_2t/12_2t13/feature/guide/ftprefrg.html
- GRE+IP encapsulation adds 24 bytes to the packet size. When configuring for prefragmentation based on anticipated GRE overhead, use this value.
- IPsec encryption adds a number of bytes to the packet size depending on the configured IPsec transform set. When configuring for prefragmentation based on anticipated IPsec overhead, use the following table of worst-case IPsec overhead bytes for various IPsec transform sets:

IPsec Transform Set	IPsec Overhead, Maximum Bytes
esp-aes-(256 or 192 or 128) esp-sha-hmac or md5	73
esp-aes (256 or 192 or 128)	61
esp-3des, esp-des	45
esp-(des or 3des) esp-sha-hmac or md5	57
esp-null esp-sha-hmac or md5	45
ah-sha-hmac or md5	44

Configuring IPsec Prefragmentation Globally

IPsec prefragmentation is globally enabled by default. To enable or disable prefragmentation for IPsec VPNs at the global level, perform this task beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# crypto ipsec fragmentation before-encryption`	Enables prefragmentation for IPsec VPNs globally.
Step 2	`Router(config)# crypto ipsec fragmentation after-encryption`	Disables prefragmentation for IPsec VPNs globally.

Configuring IPsec Prefragmentation at the Interface

IPsec prefragmentation is globally enabled by default. To enable or disable prefragmentation for IPsec VPNs at the interface level, perform this task beginning in interface configuration mode for the interface to which the crypto map is attached:

	Command	Purpose
Step 1	`Router(config-if)# crypto ipsec fragmentation before-encryption`	Enables prefragmentation for IPsec VPNs on the interface.
Step 2	`Router(config-if)# crypto ipsec fragmentation after-encryption`	Disables prefragmentation for IPsec VPNs on the interface.

Note Enabling or disabling IPsec prefragmentation at the interface will override the global configuration.

Verifying the IPsec Prefragmentation Configuration

To verify that IPsec prefragmentation is enabled, consult the interface statistics on the encrypting switch and the decrypting switch. If fragmentation occurs on the encrypting switch, and no reassembly occurs on the decrypting switch, fragmentation is occurring before encryption, which means that the packets are not being reassembled before decryption and the feature is enabled.

To verify that the IPsec prefragmentation feature is enabled, enter the **show running-configuration** command on the encrypting switch. If the feature is enabled, no fragmentation feature will appear in the command output:

```
Router# show running-configuration

crypto isakmp policy 10
 authentication pre-share
crypto isakmp key abcd123 address 25.0.0.7
crypto ipsec transform-set fooprime esp-3des esp-sha-hmac
!!! the postfragmentation feature appears here if IPsec prefragmentation is disabled
crypto map bar 10 ipsec-isakmp
 set peer 25.0.0.7
 set transform-set fooprime
 match address 102
```

If IPsec prefragmentation has been disabled, the postfragmentation feature will appear in the command output:

```
Router# show running-configuration

crypto isakmp policy 10
 authentication pre-share
crypto isakmp key abcd123 address 25.0.0.7
crypto ipsec transform-set fooprime esp-3des esp-sha-hmac
crypto ipsec fragmentation after-encryption
crypto map bar 10 ipsec-isakmp
 set peer 25.0.0.7
 set transform-set fooprime
 match address 102
```

To display the configuration of the encrypting switch interface VLAN, enter the **show running-configuration interface** command. If the IPsec prefragmentation feature is enabled, a prefragmentation statement will appear in the command output:

```
Router# show running-configuration interface vlan2

interface Vlan2
 ip address 15.0.0.2 255.255.255.0
 crypto map testtag
 crypto engine slot 1/0
 crypto ipsec fragmentation before-encryption
```

If the IPsec prefragmentation feature has been disabled at the interface VLAN, a postfragmentation statement will appear in the command output:

```
Router# show running-configuration interface vlan2

interface Vlan2
 ip address 15.0.0.2 255.255.255.0
 crypto map testtag
 crypto engine slot 1/0
 crypto ipsec fragmentation after-encryption end
```

Configuring MTU Settings

The Cisco IOS software allows the configuration of the Layer 3 maximum transmission unit (MTU) of interfaces and VLANs. You should ensure that all MTU values are consistent to avoid unnecessary fragmentation of packets.

Note When configuring MTU, note that the **ip mtu** command applies only to IP protocol traffic. Other Layer 3 protocol traffic will observe the MTU configured by the **mtu** command.

MTU Settings Configuration Guidelines and Restrictions

When configuring MTU settings for an IPsec VPN SPA, follow these guidelines and note these restrictions:

- In Cisco IOS Release 12.2(33)SXH and earlier releases, the MTU value used by the IPsec VPN SPA for fragmentation decisions is based on the MTU value of the secure port as follows:

  - Routed ports—Use the MTU value of their associated secure port.
  - Access ports—Use the MTU value of the secure port associated with their interface VLAN.
  - Trunk ports—Use the MTU value of the secure port associated with their interface VLAN.
- In Cisco IOS Release 12.2(33)SXI and later releases, the MTU value used by the IPsec VPN SPA for fragmentation decisions is based on the IP MTU of the tunnel or of the crypto interface VLAN, not the egress interface. For information on the recommended MTU settings, see the "Fragmentation in Cisco IOS Release 12.2(33)SXI and Later Releases" section on page 23-10.
- If you have GRE tunneling configured, see the "Fragmentation in Cisco IOS Release 12.2(33)SXH and Earlier Releases" section on page 23-3 or the "Fragmentation in Cisco IOS Release 12.2(33)SXI and Later Releases" section on page 23-10 for information on the recommended MTU settings.

Note For additional information on fragmentation of packets, see the "Configuring IPsec Prefragmentation" section on page 23-16.

Changing the Physical Egress Interface MTU

You can configure either the Layer 3 MTU or the IP MTU of the physical egress interface. To change the MTU value on a physical egress interface, perform this task beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# interface type[1] slot/port`	Enters interface configuration mode for the interface.
Step 2	`Router(config-if)# mtu bytes`	Configures the maximum transmission unit (MTU) size for the interface. • *bytes*—The range is 1500 to 9216; the default is 1500.

[1] *type* = **fastethernet**, **gigabitethernet**, or **tengigabitethernet**

Changing the Tunnel Interface IP MTU

You can configure the IP MTU of the tunnel interface, but you cannot configure the Layer 3 MTU. To change the IP MTU value on a tunnel, perform this task beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# interface tunnel_name`	Enters interface configuration mode for the tunnel.
Step 2	`Router(config-if)# ip mtu bytes`	Configures the IP MTU size for the tunnel. • *bytes*—The minimum is 68; the maximum and the default depend on the interface medium.

Changing the Interface VLAN MTU

You can configure the Layer 3 MTU of the interface VLAN. To change the MTU value on an interface VLAN, perform this task beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# interface vlan_ID`	Enters interface configuration mode for the VLAN.
Step 2	`Router(config-if)# mtu bytes`	Configures the MTU size for the interface VLAN. • *bytes*—The range is 64 to 9216; the default is 1500.

Verifying the MTU Size

To verify the MTU size for an interface, enter the **show interface** command or the **show ip interface** command, as shown in the following examples:

To display the MTU value for a secure port, enter the **show interface** command:

```
Router# show interface g1/1

GigabitEthernet1/1 is up, line protocol is up (connected)
Hardware is C6k 1000Mb 802.3, address is 000a.8ad8.1c4a (bia 000a.8ad8.1c4a)
MTU 9216 bytes, BW 1000000 Kbit, DLY 10 usec,
reliability 255/255, txload 1/255, rxload 1/255
...
```

To display the MTU size for an interface VLAN, enter the **show interface** command.

```
Router# show interface vlan2
Vlan2 is up, line protocol is up
  Hardware is EtherSVI, address is 000e.39ad.e700 (bia 000e.39ad.e700)
  Internet address is 192.168.1.1/16
  MTU 1000 bytes, BW 1000000 Kbit, DLY 10 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
...
```

To display the IP MTU value for a GRE tunnel, enter the **show ip interface** command:

```
Router# show ip interface tunnel 2

Tunnel2 is up, line protocol is up
Internet address is 11.1.0.2/16
Broadcast address is 255.255.255.255
Address determined by non-volatile memory
MTU is 1450 bytes
...
```

Configuration Examples

The following sections provide examples of IPsec prefragmentation configurations using commands at the level of Cisco IOS Release 12.2(33)SXI:

- Crypto-Connect Mode IPsec Prefragmentation Configuration Example, page 23-21

- VRF Mode with GRE using Tunnel Protection IPsec Prefragmentation Configuration Example, page 23-22

Crypto-Connect Mode IPsec Prefragmentation Configuration Example

The following example shows an IPsec prefragmentation configuration using crypto-connect mode:

```
!
hostname router-1
!
vlan 2,502
!
crypto isakmp policy 1
 encr 3des
 authentication pre-share
crypto isakmp key 12345 address 11.0.0.1
!
!
crypto ipsec transform-set proposal1 esp-3des esp-md5-hmac
!
crypto map testtag 10 ipsec-isakmp
 set peer 11.0.0.1
 set transform-set proposal1
 match address 101
!
!
interface GigabitEthernet1/1
  !switch inside port
  ! mtu 1500 by default
  ip address 13.0.0.1 255.255.255.0
!
interface GigabitEthernet1/2
 !switch outside port
  mtu 1000
  switchport
  switchport access vlan 502
  switchport mode access
!
interface GigabitEthernet4/0/1
  !IPsec VPN SPA inside port
  switchport
  switchport trunk encapsulation dot1q
  switchport trunk allowed vlan 1,2,1002-1005
  switchport mode trunk
  mtu 9216
  flowcontrol receive on
  flowcontrol send off
  spanning-tree portfast trunk
!
interface GigabitEthernet4/0/2
  !IPsec VPN SPA outside port
  switchport
  switchport trunk encapsulation dot1q
  switchport trunk allowed vlan 1,502,1002-1005
  switchport mode trunk
  mtu 9216
  flowcontrol receive on
  flowcontrol send off
  spanning-tree portfast trunk
!
interface Vlan2
```

```
 !interface vlan
  mtu 1000
  ip address 11.0.0.2 255.255.255.0
  crypto map testtag
  crypto engine slot 4/0
!
interface Vlan502
  !port vlan
  no ip address
  crypto connect vlan 2
!
ip classless
ip route 12.0.0.0 255.0.0.0 11.0.0.1
!
access-list 101 permit ip host 13.0.0.2 host 12.0.0.2
!
end
```

VRF Mode with GRE using Tunnel Protection IPsec Prefragmentation Configuration Example

The following example shows an IPsec prefragmentation configuration using VRF mode with GRE and tunnel protection:

```
!
hostname router-1
!
ip vrf coke
 rd 1000:1
 route-target export 1000:1
 route-target import 1000:1
!
crypto keyring key1
 pre-shared-key address 100.1.1.1 key happy-eddie
!
crypto isakmp policy 1
 authentication pre-share
crypto isakmp profile prof1
 keyring key1
 match identity address 100.1.1.1 255.255.255.255
!
crypto ipsec transform-set TR esp-des esp-md5-hmac
 mode transport
!
crypto ipsec profile tp
 set transform-set TR
 set isakmp-profile prof1
!
!
crypto engine mode vrf
!
interface Tunnel1
  ip mtu 1400
  ip vrf forwarding coke
  ip address 10.1.1.254 255.255.255.0
  tunnel source 172.1.1.1
  tunnel destination 100.1.1.1
  tunnel protection ipsec profile tp
  crypto engine slot 4/0 inside
!
```

```
interface GigabitEthernet4/0/1
  !IPsec VPN SPA inside port
  flowcontrol receive on
  flowcontrol send off
  switchport
  switchport trunk encapsulation dot1q
  switchport trunk allowed vlan 1,1002-1005
  switchport mode trunk
  cdp enable
  spanning-tree portfast trunk
!
interface GigabitEthernet4/0/2
  !IPsec VPN SPA outside port
  no ip address
  flowcontrol receive on
  flowcontrol send off
  switchport
  switchport trunk encapsulation dot1q
  switchport trunk allowed vlan 1,1002-1005
  switchport mode trunk
  cdp enable
  spanning-tree portfast trunk
!
interface GigabitEthernet6/1
  ! mtu 1500 by default
  ip address 172.1.1.1 255.255.255.0
  crypto engine slot 4/0 outside
!
interface FastEthernet7/13
  ip vrf forwarding coke
  ip address 13.1.1.2 255.255.255.0
!
ip route 100.1.1.1 255.255.255.255 Tunnel1
end
```