Virtual Fragmentation Reassembly

Virtual fragmentation reassembly (VFR) is automatically enabled by some features (such as NAT, Cisco IOS XE Firewall, IPSec) to get Layer 4 or Layer 7 information. VFR enables the Cisco IOS XE Firewall to create appropriate dynamic access control lists (ACLs) to protect the network from various fragmentation attacks.

Most non-initial fragments do not have the Layer 4 header because it usually travels with the initial fragments (except in the case of micro-fragmentation and tiny fragments). Due to this, some features (such as NAT, Cisco IOS XE Firewall, IPSec) are unable to gather port information from the packet. These features may need to inspect the Layer 7 payload, for which the fragments need to be reassembled, and then refragmented later.

Note From Cisco IOS XE Release 17.7.1, when you are running a Cisco IOS-XE router as an SSL VPN gateway, an extra SSL VPN overhead is added due to the TLS encapsulation. To prevent IP fragmentation and reassembly of packets between SSL VPN client and server, you must adjust the TCP-MSS value optimally. Otherwise, packet drop due to the IPFragErr error could occur in the SSL VPN gateway. This guideline is applicable for the Cisco 4400 Series ISR platform.

Restrictions for Virtual Fragmentation Reassembly

Performance Impact

VFR causes a performance impact on the basis of functions such as packet copying, fragment validation, and fragment reorder. This performance impact varies depending on the number of concurrent IP datagrams that are being reassembled.

VFR Configuration

The reassembly process requires all fragments within an IP datagram. If fragments within an IP datagram are sent to different devices due to load balancing (per packet load balancing or include ports on Cisco Catalyst 6500 Series Switches or Cisco Nexus devices), VFR may fail and fragments may be dropped.

Information About Virtual Fragmentation Reassembly

VFR Detection of Fragment Attacks

VFR is responsible for detecting and preventing the following types of fragment attacks:

- Tiny fragment attack—In this type of attack, the attacker makes the fragment size small enough to force Layer 4 (TCP and UDP) header fields into the second fragment. Thus, the ACL rules that have been configured for those fields do not match.
- VFR drops all tiny fragments, and an alert message such as "VFR-3-TINY_FRAGMENTS" is logged to the syslog server.
- Overlapping fragment attack—In this type of attack, the attacker can overwrite the fragment offset in the noninitial IP fragment packets. When the firewall reassembles the IP fragments, it might create wrong IP packets, causing the memory to overflow or the system to reload.
- VFR drops all fragments within a fragment chain if an overlap fragment is detected.
- Buffer overflow attack—In this type of denial-of-service (DoS) attack, the attacker can continuously send a large number of incomplete IP fragments, causing the firewall to consume time and memory while trying to reassemble the fake packets.

To avoid buffer overflow and control memory use, configure a maximum threshold for the number of IP datagrams that are being reassembled and the number of fragments per datagram. You can use the **ip virtual-reassembly** command or the **ip virtual-reassembly-out** command to specify these parameters.

When the maximum number of datagrams that can be reassembled at any given time is reached, all subsequent fragments are dropped, and the global statistics item "ReassDrop" is incremented by one.

When the maximum number of fragments per datagram is reached, subsequent fragments are dropped, and the global statistics item "ReassTooManyFrags" is incremented by one.

In addition to the maximum threshold values being configured, each IP datagram is associated with a managed timer. If the IP datagram does not receive all of the fragments within the specified time, the timer expires and the IP datagram and all of its fragments are dropped.

VFR Enablement

VFR is designed to work with any feature that requires fragment reassembly (such as Cisco IOS XE Firewall, NAT, and IPSec). By default, NAT, Cisco IOS XE Firewall, Crypto-based IPSec, NAT64, and onePK enable and disable VFR internally; that is, when these features are enabled on an interface, VFR is automatically enabled on that interface.

If more than one feature attempts to automatically enable VFR on an interface, VFR maintains a reference count to keep track of the number of features that have enabled VFR. When the reference count is reduced to zero, VFR is automatically disabled.

If NAT is enabled on an interface (such as GigabitEthernet 0/0/0), VFR (input/output) is enabled on this interface.

```
Device(config-if)# do show ip virtual-reassembly features
GigabitEthernet0/0/0:
  Virtual Fragment Reassembly (VFR) Current Status is ENABLED [in]
  Features to use if VFR is Enabled:NAT
GigabitEthernet0/0/0:
  Virtual Fragment Reassembly (VFR) Current Status is ENABLED [out]
  Features to use if VFR is Enabled:NAT
```

If Cisco IOS XE Firewall is enabled on an interface (such as GigabitEthernet 0/0/0), VFR (out) is enabled on this interface.

```
Device(config-if)# do show ip virtual-reassembly features
GigabitEthernet0/0/0:
  Virtual Fragment Reassembly (VFR) Current Status is ENABLED [out]
  Features to use if VFR is Enabled:FW
```

If IPSec is enabled on an interface (such as GigabitEthernet 0/0/0), VFR (out) is enabled on this interface.

```
Device(config-if)# do show ip virtual-reassembly features
GigabitEthernet0/0/0:
  Virtual Fragment Reassembly (VFR) Current Status is ENABLED [out]
  Features to use if VFR is Enabled:IPSec
```

Note If VFR is enabled by features such as NAT and Cisco IOS XE Firewall, the **ip virtual-reassembly [-out]** command is not displayed in the output of the **show running-config** command.

VFR can be manually enabled or disabled using the [**no**] **ip virtual-reassembly [-out]** command.

If VFR is manually enabled, regardless of whether it is enabled by features such as NAT and Cisco IOS XE Firewall, the **ip virtual-reassembly [-out]** command is displayed in the output of the **show running-config** command.

VFR Disablement

You can disable virtual fragmentation reassembly (VFR) using the following methods:

- If VFR is manually enabled, it can be manually disabled using the **no ip virtual-reassembly [-out]** command. This command is not displayed in the output of the **show running-config** command.
- If VFR is enabled by a feature (such as NAT or Cisco IOS Firewall), it can be manually disabled or it can be disabled by disabling the feature. If it is manually disabled, the **no ip virtual-reassembly [-out]** command is displayed in the output of the **show running-config** command.
- If VFR is both manually enabled and enabled by features, it can be manually disabled using the **no ip virtual-reassembly [-out]** command. This command is displayed in the output of the **show running-config** command.

Note If VFR is not enabled, the **no ip virtual-reassembly [-out]** command is not displayed in the output of the **show running-config** command.

To enable VFR after it is disabled, that is, when the **no ip virtual-reassembly [-out]** command is displayed in the output of the **show running-config** command, manually enable VFR using the **ip virtual-reassembly [-out]** command or disable related features and then enable the features again.

In a crypto map-based IPSec deployment scenario (such as GETVPN), VFR is enabled by default in devices which are configured with IPSec. Fragments of the same packet may be sent to different devices (which are IPSec-enabled) by upper devices due to the packet load balance algorithm (per packet load balance or per destination on some Nexus devices). VFR may drop the fragments if it does not receive all fragment of the same IP packet. The recommended workaround of this issue is to change the load balance algorithm to ensure all fragments of the same packet go to the same path. If Layer 4 information (ports) is not a filter criterion in IPSec policy, another workaround is to manually disable VFR using **no ip virtual-reassembly [-out]** on interfaces where IPSec is configured.

VFR on Outbound Interfaces

In Cisco IOS XE Release 3.2S and later releases, you can use the **ip virtual-reassembly-out** command to manually enable or disable VFR on outbound interface traffic.

How to Configure Virtual Fragmentation Reassembly

Configuring VFR

Perform this task to enable VFR on an interface to specify maximum threshold values to combat buffer overflow and control memory usage, and to verify any VFR configurations.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-type interface-number*
4. **ip virtual-reassembly** [**max-reassemblies** *number*] [**max-fragments** *number*] [**timeout** *seconds*] [**drop-fragments**]
5. **end**
6. **show ip virtual-reassembly** [*interface type*]

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode.

	Command or Action	Purpose
	Example: `Device> enable`	• Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-type interface-number* **Example:** `Device(config)# interface GigabitEthernet0/0/1`	Configures an interface type and enters interface configuration mode.
Step 4	**ip virtual-reassembly** [**max-reassemblies** *number*] [**max-fragments** *number*] [**timeout** *seconds*] [**drop-fragments**] **Example:** `Device(config-if)# ip virtual-reassembly max-reassemblies 64 max-fragments 16 timeout 5`	Enables VFR on the interface and specifies the maximum threshold values.
Step 5	**end** **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.
Step 6	**show ip virtual-reassembly** [*interface type*] **Example:** `Device# show ip virtual-reassembly GigabitEthernet0/0/1`	Displays the configuration and statistical information of the VFR. • If an interface is not specified, VFR information is shown for all configured interfaces.

Enabling VFR Manually on Outbound Interface Traffic

Perform this task to enable VFR manually on outbound interface traffic. You can use this procedure to reenable VFR on outbound interface traffic if it is disabled, for example, by the **no ip virtual-reassembly** command.

Note If VFR is enabled on both inbound and outbound interface traffic, you can use the **no ip virtual-reassembly [-out]** command to disable it on only the outbound interface traffic.

SUMMARY STEPS

1. **enable**
2. **configure terminal**

3. **interface** *type number*
4. **ip virtual-reassembly** [**max-reassemblies** *number*] [**max-fragments** *number*] [**timeout** *seconds*] [**drop-fragments**]
5. **end**

DETAILED STEPS

Procedure

	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** *type number* **Example:** `Device(config)# interface GigabitEthernet0/0/1`	Configures an interface type and enters interface configuration mode.
Step 4	**ip virtual-reassembly** [**max-reassemblies** *number*] [**max-fragments** *number*] [**timeout** *seconds*] [**drop-fragments**] **Example:** `Device(config-if)# ip virtual-reassembly max-reassemblies 64 max-fragments 16 timeout 5`	Enables VFR on the interface and specifies the maximum threshold values.
Step 5	**end** **Example:** `Device(config-if)# end`	Exits interface configuration mode.

Troubleshooting Tips

To display debugging messages related to the VFR subsystem, use the **debug ip virtual-reassembly** command.

Configuration Examples for Virtual Fragmentation Reassembly

Example: Configuring VFR on Outbound Interface Traffic

The following example shows how to manually enable VFR on outbound traffic on interfaces GigabitEthernet0/0/1, GigabitEthernet0/0/0.773, and Serial 3/0:

```
interface Loopback 0
 ip address 10.0.1.1 255.255.255.255
 !
interface GigabitEthernet0/0/1
 description LAN1
 ip address 10.4.0.2 255.255.255.0
 ip virtual-reassembly-out
 !
interface GigabitEthernet0/0/0.773
 encapsulation dot1Q 773
 description LAN2
 ip address 10.15.0.2 255.255.255.0
 ip virtual-reassembly-out
 !
interface Serial 3/0
 description Internet
 ip unnumbered Loopback0
 encapsulation ppp
 ip virtual-reassembly-out
 serial restart-delay 0
```

Additional References for Virtual Fragmentation Reassembly

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Command List, All Releases
Dynamic IDS	Cisco IOS Intrusion Prevention System
CBAC	“Configuring Context-Based Access Control” chapter

RFCs

RFCs	Title
RFC 791	*Internet Protocol*
RFC 1858	*Security Considerations for IP Fragment Filtering*

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

Feature Information for Virtual Fragmentation Reassembly

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 Virtual Fragmentation Reassembly

Feature Name	Releases	Feature Information
Virtual Fragmenatation Reassembly	Cisco IOS XE Release 3.2S	VFR enables the Cisco IOS Firewall to create the appropriate dynamic ACLs to protect the network from various fragmentation attacks. In Cisco IOS Release XE 3.2S, functionality to manually configure VFR for outbound or inbound interface traffic was added. The following commands were introduced or modified: **ip virtual-reassembly-out, show ip virtual-reassembly**.