为站点间 IPSec VPN 配置高可用特性

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简介

本文档介绍站点到站点IPSec VPN网络的高可用性新功能。热备份路由器协议(HSRP)通常用于跟踪路由器的接口状态以实现路由器之间的故障切换。但是，由于IPSec和HSRP之间不存在内部关联，因此HSRP不跟踪IPSec安全关联(SA)的状态，IPSec在发生时需要方案以与HSRP故障切换同步。以下是用于在IPSec和HSRP之间提供更紧密耦合的方案的一些亮点：

- 互联网密钥交换(IKE)保活用于允许IPSec及时检测HSRP故障切换。
- 在特定路由器接口上应用的加密映射与该接口上已配置的HSRP组相链接，以使IPSec了解HSRP设置。这还允许IPSec将HSRP虚拟IP地址用作HSRP路由器的互联网安全关联和密钥管理协议(ISAKMP)标识。
- 反向路由注入(RRI)功能用于在HSRP和IPSec故障切换期间允许动态路由信息更新。

注意：本文档介绍如何将热备份路由器协议(HSRP)与VPN配合使用。HSRP还用于跟踪发生故障的ISP链路。要在路由器上配置冗余ISP链路，请参阅使用ICMP回显操作分析IP服务级别。源设备是路由器，目的设备是ISP设备。

先决条件

要求

本文档没有任何特定的前提条件。

使用的组件

本文档中的信息基于以下软件和硬件版本：

- Cisco 7200 系列路由器
- 思科IOS®软件版本12.3(7)T1,c7200-a3jk9s-mz.123-7.T1

本文档中的信息都是基于特定实验室环境中的设备创建的。本文档中使用的所有设备最初均采用原始（默认）配置。如果您是在真实网络上操作，请确保您在使用任何命令前已经了解其潜在影响。

规则

有关文档规则的详细信息，请参阅 Cisco 技术提示规则。

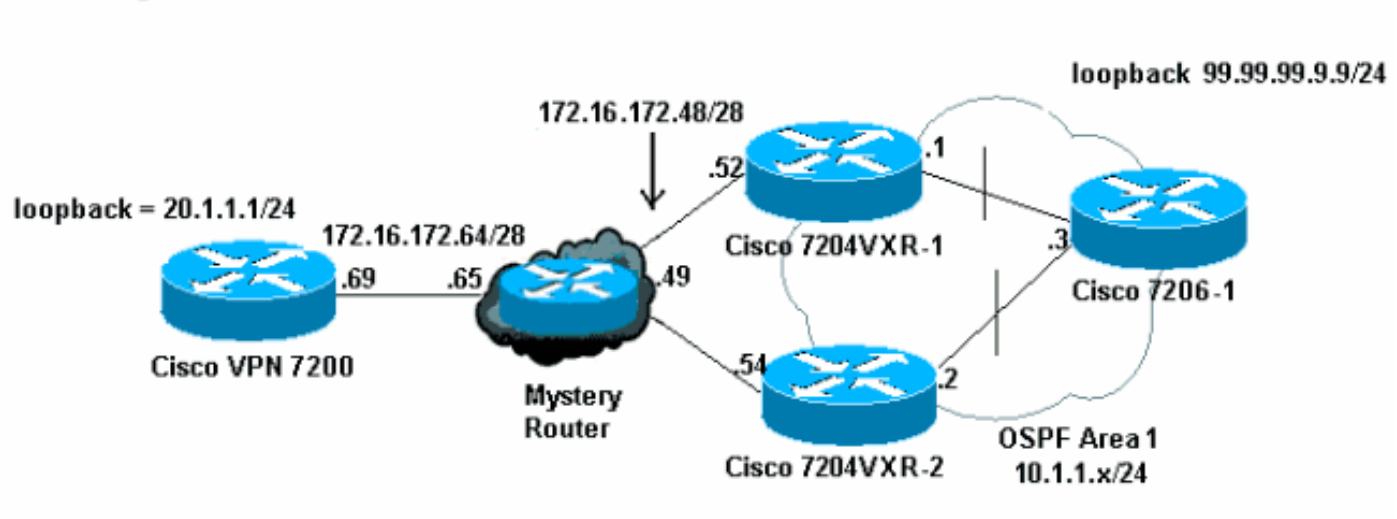
配置

本部分提供有关如何配置本文档所述功能的信息。

注意：使用命令查找工具(仅限注册客户)可获取有关本节中使用的命令的详细信息。

网络图

本文档使用以下网络设置：



配置

本文档使用以下配置：

- Cisco VPN 7200配置
- 思科7204VXR-1配置
- 思科7204VXR-2配置
- Cisco 7206-1配置

Cisco VPN 7200配置

```
vpn7200#show run
Building configuration...
```

```
Current configuration : 1854 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname vpn7200
!
!
ip subnet-zero
ip cef
!--- Defines ISAKMP policy and IKE pre-shared key for !-
-- IKE authentication. Note that 172.16.172.53 is the !-
-- HSRP virtual IP address of the remote HSRP routers.
crypto isakmp policy 1 hash md5 authentication pre-share
crypto isakmp key cisco123 address 172.16.172.53 !---
IKE keepalive to detect the IPSec liveness of the remote
!--- VPN router. When HSRP failover happens, IKE
keepalive !--- will detect the HSRP router switchover.
crypto isakmp keepalive 10 ! ! crypto ipsec transform-
set myset esp-des esp-md5-hmac !--- Defines crypto map.
Note that the peer address is the !--- HSRP virtual IP
address of the remote HSRP routers. crypto map vpn 10
ipsec-isakmp set peer 172.16.172.53 set transform-set
myset match address 101 ! interface Loopback0 ip address
20.1.1.1 255.255.255.255 ! interface FastEthernet0/0 ip
address 10.48.66.66 255.255.254.0 duplex full speed 100
! interface FastEthernet0/1 ip address 172.16.172.69
255.255.255.240 duplex full speed 100 crypto map vpn !
ip classless ip route 10.1.1.0 255.255.255.0
172.16.172.65 ip route 99.99.99.99 255.255.255.255
172.16.172.65 ip route 172.16.172.48 255.255.255.240
172.16.172.65 no ip http server ! access-list 101 permit
ip 20.1.1.0 0.0.0.255 10.1.1.0 0.0.0.255 access-list 101
permit ip 20.1.1.0 0.0.0.255 host 99.99.99.99 ! line con
0 exec-timeout 0 0 line aux 0 line vty 0 4 login ! end
```

思科7204VXR-1配置

```
7204VXR-1#show run
Building configuration...

Current configuration : 1754 bytes
!
version 12.3
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname 7204VXR-1
!
boot-start-marker
boot-end-marker
!
!
no aaa new-model
ip subnet-zero
!
!
no ip domain lookup
!
!
```

```
ip cef!
!--- Defines ISAKMP policy. crypto isakmp policy 1 hash
md5 authentication pre-share crypto isakmp key cisco123
address 172.16.172.69 crypto isakmp keepalive 10 ! !
crypto ipsec transform-set myset esp-des esp-md5-hmac !-
-- Defines crypto map. Note that "reverse-route" !---
turns on the RRI feature. crypto map vpn 10 ipsec-isakmp
set peer 172.16.172.69 set transform-set myset match
address 101 reverse-route ! ! !--- Define HSRP under the
interface. HSRP will track the !--- internal interface
as well. HSRP group name must be !--- defined here and
will be used for IPSec configuration. !--- The
"redundancy" keyword in the crypto map command !---
specifies the HSRP group to which IPSec will couple. !--
- In normal circumstances, this router will be the HSRP
!--- primary router since it has higher priority than
the !--- other HSRP router. interface FastEthernet0/0 ip
address 172.16.172.52 255.255.255.240 duplex full speed
100 standby 1 ip 172.16.172.53 standby 1 priority 200
standby 1 preempt standby 1 name VPNHA standby 1 track
FastEthernet0/1 150 crypto map vpn redundancy VPNHA !
interface FastEthernet0/1 ip address 10.1.1.1
255.255.255.0 duplex full speed 100 ! interface ATM1/0
no ip address shutdown no atm ilmi-keepalive ! interface
FastEthernet3/0 no ip address shutdown duplex half !
interface ATM6/0 no ip address shutdown no atm ilmi-
keepalive !--- Define dynamic routing protocol and re-
distribute static !--- route. This enables dynamic
routing information update !--- during the HSRP/IPSec
failover. All the "VPN routes" !--- that are injected in
the routing table by RRI as static !--- routes will be
redistributed to internal networks. ! router ospf 1 log-
adjacency-changes redistribute static subnets network
10.1.1.0 0.0.0.255 area 0 ! ip classless ip route
172.16.172.64 255.255.255.240 172.16.172.49 no ip http
server no ip http secure-server ! ! !--- Defines VPN
traffic. The destination IP subnet will be !--- injected
into the routing table as static routes by RRI. access-
list 101 permit ip 10.1.1.0 0.0.0.255 20.1.1.0 0.0.0.255
access-list 101 permit ip host 99.99.99.99 20.1.1.0
0.0.0.255 ! line con 0 exec-timeout 0 0 stopbits 1 line
aux 0 stopbits 1 line vty 0 4 ! ! ! end
```

思科7204VXR-2配置

```
7204VXR-2#show run
Building configuration...

Current configuration : 2493 bytes
!
version 12.3
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname 7204VXR-2
!
boot-start-marker
boot system flash disk1:c7200-a3jk9s-mz.123-7.T1
boot-end-marker
!
no aaa new-model
ip subnet-zero
```

```
!
!
no ip domain lookup
ip host rund 10.48.92.61
!
!
ip cef
!
crypto isakmp policy 1
hash md5
authentication pre-share
crypto isakmp key cisco123 address 172.16.172.69
crypto isakmp keepalive 10
!
!
crypto ipsec transform-set myset esp-des esp-md5-hmac
!
crypto map vpn 10 ipsec-isakmp
set peer 172.16.172.69
set transform-set myset
match address 101
reverse-route
!
!--- During normal operational conditions this router !-
-- will be the standby router. interface FastEthernet0/0
ip address 172.16.172.54 255.255.255.240 ip directed-
broadcast duplex full standby 1 ip 172.16.172.53 standby
1 preempt standby 1 name VPNHA standby 1 track
FastEthernet1/0 crypto map vpn redundancy VPNHA !
interface FastEthernet1/0 ip address 10.1.1.2
255.255.255.0 ip directed-broadcast duplex full !
interface FastEthernet3/0 ip address 10.48.67.182
255.255.254.0 ip directed-broadcast shutdown duplex full
! router ospf 1 log-adjacency-changes redistribute
static subnets network 10.1.1.0 0.0.0.255 area 0 ! ip
classless ip route 172.16.172.64 255.255.255.240
172.16.172.49 no ip http server no ip http secure-server
! ! ! access-list 101 permit ip 10.1.1.0 0.0.0.255
20.1.1.0 0.0.0.255 access-list 101 permit ip host
99.99.99.99 20.1.1.0 0.0.0.255 ! line con 0 exec-timeout
0 0 transport preferred all transport output all
stopbits 1 line aux 0 transport preferred all transport
output all stopbits 1 line vty 0 4 login transport
preferred all transport input all transport output all !
! ! end
```

Cisco 7206-1配置

```
7206-1#show run
Building configuration...

Current configuration : 1551 bytes
!
version 12.2
no service pad
service timestamps debug datetime msec localtime
service timestamps log datetime msec localtime
no service password-encryption
!
hostname 7206-1
!
ip subnet-zero
no ip source-route
```

```
ip cef
!
interface Loopback0
ip address 99.99.99.99 255.255.255.255
!
interface FastEthernet0/0
shutdown
duplex full
speed 100
!
!--- Define dynamic routing protocol. All the "VPN
routes" !--- will be learned and updated dynamically
from upstream HSRP !--- routers using the dynamic
routing protocols. interface FastEthernet0/1 ip address
10.1.1.3 255.255.255.0 duplex full speed 100 ! router
ospf 1 log-adjacency-changes passive-interface Loopback0
network 10.1.1.0 0.0.0.255 area 0 network 99.99.99.99
0.0.0.0 area 0 ! ip classless no ip http server ! ! !
line con 0 exec-timeout 0 0 line aux 0 line vty 0 4
login ! end
```

它如何运转?

本示例演示了HSRP和IPSec故障切换如何使用上述设置和配置协同工作。本案例研究重点介绍三个方面：

- 由于接口故障，HSRP故障切换。
- IPSec故障切换在HSRP故障切换后如何发生。如图所示，此处的IPSec故障切换将是“无状态”故障切换。
- 故障切换导致的路由信息更改如何动态更新并传播到内部网络。

注意：此处的测试流量是Cisco 7206-1(99.99.99.99)的环回IP地址和Cisco VPN 7200(20.1.1.1)的环回IP地址之间的互联网控制消息协议(ICMP)数据包，并模拟两个站点之间的VPN流量。

正常情况（在故障切换之前）

在故障切换之前，Cisco 7204VXR-1是主HSRP路由器，而Cisco VPN 7200具有带Cisco 7204VXR-1的IPSec SA。

在接口上配置加密映射时，RRI功能会注入VPN路由以匹配加密映射中已配置的IPSec访问控制列表(ACL)和**set peer** 命令语句。此路由已添加到主HSRP路由器7204VXR-1的路由表中。

debug crypto ipsec命令**的输出**表明VPN路由20.1.1/24添加到路由信息库(RIB)。

```
IPSEC(rte_mgr): VPN Route Added 20.1.1.0 255.255.255.0
via 172.16.172.69 in IP DEFAULT TABLE
```

主HSRP路由器上的路由表生成到20.1.1/24的静态路由，该路由通过开放最短路径优先(OSPF)重新分发到辅助HSRP路由器7204VXR-2和内部路由器7206-1。

VPN路由20.1.1/24的下一跳是远程加密对等体的IP地址，它作为静态路由注入到路由器7204VXR-1的RIB中。在这种情况下，VPN路由20.1.1/24的下一跳是172.16.172.69。VPN路由下一跳的IP地址通过递归路由查找进行解析，如下面的思科快速转发表所示：

```
7204VXR-1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF,
       IA - OSPF inter area, N1 - OSPF NSSA external type 1,
       N2 - OSPF NSSA external type 2, E1 - OSPF external type 1,
       E2 - OSPF external type 2, i - IS-IS, su - IS-IS summary,
       L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
       * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

    99.0.0.0/32 is subnetted, 1 subnets
O     99.99.99.99 [110/2] via 10.1.1.3, 00:11:21, FastEthernet0/1
    20.0.0.0/24 is subnetted, 1 subnets
S     20.1.1.0 [1/0] via 172.16.172.69
    172.16.0.0/28 is subnetted, 2 subnets
C     172.16.172.48 is directly connected, FastEthernet0/0
S      172.16.172.64 [1/0] via 172.16.172.49
    10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C     10.1.1.0/24 is directly connected, FastEthernet0/1
S      10.48.66.0/23 [1/0] via 10.1.1.2


7204VXR-1#show ip cef 20.1.1.0 detail
20.1.1.0/24, version 66, epoch 0, cached adjacency 172.16.172.49
0 packets, 0 bytes
via 172.16.172.69, 0 dependencies, recursive
next hop 172.16.172.49, FastEthernet0/0 via 172.16.172.64/28
valid cached adjacency
```

辅助HSRP路由器和内部路由器7206-1通过OSPF/获取此VPN路由。网络管理员无需手动输入静态路由。更重要的是，故障切换导致的路由更改会动态更新。

```
7204VXR-2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF,
       IA - OSPF inter area, N1 - OSPF NSSA external type 1,
       N2 - OSPF NSSA external type 2, E1 - OSPF external type 1,
       E2 - OSPF external type 2, i - IS-IS, su - IS-IS summary,
       L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
       * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 10.48.66.1 to network 0.0.0.0

    99.0.0.0/32 is subnetted, 1 subnets
O     99.99.99.99 [110/2] via 10.1.1.3, 00:29:31, FastEthernet1/0
    20.0.0.0/24 is subnetted, 1 subnets
O E2     20.1.1.0 [110/20] via 10.1.1.1, 00:11:06, FastEthernet1/0
    172.16.0.0/28 is subnetted, 2 subnets
C     172.16.172.48 is directly connected, FastEthernet0/0
S      172.16.172.64 [1/0] via 172.16.172.49
    10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C      10.1.1.0/24 is directly connected, FastEthernet1/0
C      10.48.66.0/23 is directly connected, FastEthernet3/0
S*     0.0.0.0/0 [1/0] via 10.48.66.1


7206-1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF,
       IA - OSPF inter area, N1 - OSPF NSSA external type 1,
```

```
        N2 - OSPF NSSA external type 2, E1 - OSPF external type 1,
        E2 - OSPF external type 2, i - IS-IS, su - IS-IS summary,
        L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
        * - candidate default, U - per-user static route
        o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

    99.0.0.0/32 is subnetted, 1 subnets
C     99.99.99.99 is directly connected, Loopback0
    20.0.0.0/24 is subnetted, 1 subnets
O E2     20.1.1.0 [110/20] via 10.1.1.1, 00:14:01, FastEthernet0/1
    172.16.0.0/28 is subnetted, 1 subnets
O E2     172.16.172.64 [110/20] via 10.1.1.1, 00:32:21, FastEthernet0/1
                                   [110/20] via 10.1.1.2, 00:32:21, FastEthernet0/1
    10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C     10.1.1.0/24 is directly connected, FastEthernet0/1
O E2     10.48.66.0/23 [110/20] via 10.1.1.2, 00:32:22, FastEthernet0/1
```

路由器7204VXR-1是跟踪内部接口Fa0/1的主HSRP路由器。

```
7204VXR-1#show standby
FastEthernet0/0 - Group 1
State is Active
2 state changes, last state change 03:21:20
Virtual IP address is 172.16.172.53
Active virtual MAC address is 0000.0c07.ac01
Local virtual MAC address is 0000.0c07.ac01 (v1 default)
Hello time 3 sec, hold time 10 sec
Next hello sent in 0.172 secs
Preemption enabled
Active router is local
Standby router is 172.16.172.54,
   priority 100 (expires in 7.220 sec)
Priority 200 (configured 200)
Track interface FastEthernet0/1 state Up decrement 150
IP redundancy name is "VPNHA" (cfgd)
```

您可以使用**show track**命令查看HSRP跟踪的所有对象的列表。

```
7204VXR-1#show track
Track 1 (via HSRP)
Interface FastEthernet0/1 line-protocol
Line protocol is Up
1 change, last change 03:18:22
Tracked by:
HSRP FastEthernet0/0 1
```

路由器7204VXR-2是备用HSRP路由器。在正常运行条件下，此设备跟踪内部接口Fa1/0。

```
7204VXR-2#show standby
FastEthernet0/0 - Group 1
State is Standby
1 state change, last state change 02:22:30
Virtual IP address is 172.16.172.53
Active virtual MAC address is 0000.0c07.ac01
Local virtual MAC address is 0000.0c07.ac01 (v1 default)
Hello time 3 sec, hold time 10 sec
Next hello sent in 0.096 secs
Preemption enabled
```

```
Active router is 172.16.172.52,
   priority 200 (expires in 7.040 sec)
Standby router is local
Priority 100 (default 100)
Track interface FastEthernet1/0 state Up decrement 10
IP redundancy name is "VPNHA" (cfgd)
```

这些与IPSec相关的**show**命令在Cisco VPN 7200路由器上生成输出，该输出演示了Cisco VPN 7200与主HSRP路由器Cisco 7204VXR-1之间的ISAKMP和IPSec SA。

```
7204VXR-1#show crypto isakmp sa detail
Codes: C - IKE configuration mode, D - Dead Peer Detection
K - Keepalives, N - NAT-traversal
X - IKE Extended Authentication
psk - Preshared key, rsig - RSA signature
renc - RSA encryption

C-id       Local       Remote     I-VRF  Encr  Hash  Auth  DH  Lifetime  Cap.
1    172.16.172.53  172.16.172.69         des   md5   psk   1  23:49:52   K
Connection-id:Engine-id = 1:1(software)


7204VXR-1#show crypto ipsec sa
interface: FastEthernet0/0
Crypto map tag: vpn, local addr. 172.16.172.53

protected vrf:
local ident (addr/mask/prot/port): (99.99.99.99/255.255.255.255/0/0)
remote ident (addr/mask/prot/port): (20.1.1.0/255.255.255.0/0/0)
current_peer: 172.16.172.69:500
PERMIT, flags={origin_is_acl,}
#pkts encaps: 5, #pkts encrypt: 5, #pkts digest: 5
#pkts decaps: 5, #pkts decrypt: 5, #pkts verify: 5
#pkts compressed: 0, #pkts decompressed: 0
#pkts not compressed: 0, #pkts compr. failed: 0
#pkts not decompressed: 0, #pkts decompress failed: 0
#send errors 0, #recv errors 0

local crypto endpt.: 172.16.172.53, remote crypto endpt.: 172.16.172.69
path mtu 1500, media mtu 1500
current outbound spi: 44E0B22B

inbound esp sas:
spi: 0x5B23F22E(1529082414)
transform: esp-des esp-md5-hmac ,
in use settings ={Tunnel, }
slot: 0, conn id: 2000, flow_id: 1, crypto map: vpn
crypto engine type: Software, engine_id: 1
sa timing: remaining key lifetime (k/sec): (4504144/2949)
ike_cookies: B57A9DC9 FA2D627B F70FEDF6 FAAF9E34
IV size: 8 bytes
replay detection support: Y

inbound ah sas:

inbound pcp sas:

outbound esp sas:
spi: 0x44E0B22B(1155576363)
transform: esp-des esp-md5-hmac ,
in use settings ={Tunnel, }
slot: 0, conn id: 2001, flow_id: 2, crypto map: vpn
crypto engine type: Software, engine_id: 1
```

```
sa timing: remaining key lifetime (k/sec): (4504145/2949)
ike_cookies: B57A9DC9 FA2D627B F70FEDF6 FAAF9E34
IV size: 8 bytes
replay detection support: Y

outbound ah sas:

outbound pcp sas:


vpn7200#show crypto isakmp sa
dst             src             state     conn-id    slot
172.16.172.53  172.16.172.69   QM_IDLE   1          0


7204VXR-2#show crypto ipsec sa
interface: FastEthernet0/1
Crypto map tag: vpn, local addr. 172.16.172.69

local ident (addr/mask/prot/port): (20.1.1.0/255.255.255.0/0/0)
remote ident (addr/mask/prot/port): (99.99.99.99/255.255.255.255/0/0)
current_peer: 172.16.172.53
PERMIT, flags={origin_is_acl,}
#pkts encaps: 10, #pkts encrypt: 10, #pkts digest 10
#pkts decaps: 10, #pkts decrypt: 10, #pkts verify 10
#pkts compressed: 0, #pkts decompressed: 0
#pkts not compressed: 0, #pkts compr. failed: 0, #pkts decompress failed: 0
#send errors 5, #recv errors 0

local crypto endpt.: 172.16.172.69, remote crypto endpt.: 172.16.172.53
path mtu 1500, ip mtu 1500
current outbound spi: 5B23F22E

inbound esp sas:
spi: 0x44E0B22B(1155576363)
transform: esp-des esp-md5-hmac ,
in use settings ={Tunnel, }
slot: 0, conn id: 2029, flow_id: 1, crypto map: vpn
sa timing: remaining key lifetime (k/sec): (4607997/2824)
IV size: 8 bytes
replay detection support: Y

inbound ah sas:

inbound pcp sas:

outbound esp sas:
spi: 0x5B23F22E(1529082414)
transform: esp-des esp-md5-hmac ,
in use settings ={Tunnel, }
slot: 0, conn id: 2030, flow_id: 2, crypto map: vpn
sa timing: remaining key lifetime (k/sec): (4607998/2824)
IV size: 8 bytes
replay detection support: Y

outbound ah sas:

outbound pcp sas:
```

在 HSRP 和 IPSec 故障切换以后

故障切换是通过关闭Cisco 7204VXR-1上的Fa0/0触发的。如果另一个接口Fa0/1关闭，您将看到类似的行为，因为HSRP还会跟踪此接口的状态。

当Cisco VPN 7200未收到发送到主HSRP路由器的IKE保活数据包的响应时，路由器会拆除IPSec SA。

此**debug crypto isakmp**命令输出显示IKE保活如何检测主路由器的中断：

```
ISAKMP (0:1): received packet from 172.16.172.53 (I) QM_IDLE
ISAKMP (0:1): processing HASH payload. message ID = 1585108592
ISAKMP (0:1): processing NOTIFY ITS_ALIVE protocol 1
spi 0, message ID = 1585108592, sa = 61C3E754
ISAKMP (0:1): sending packet to 172.16.172.53 (I) QM_IDLE
ISAKMP (0:1): purging node -1484552386
ISAKMP (0:1): deleting node 1585108592 error FALSE
   reason "informational (in) state 1"
ISAKMP (0:1): purging node 642343711
ISAKMP (0:1): sending packet to 172.16.172.53 (I) QM_IDLE
ISAKMP (0:1): purging node -523181212
ISAKMP (0:1): purging node -2089541867
ISAKMP (0:1): incrementing error counter on sa: PEERS_ALIVE_TIMER
ISAKMP (0:1): sending packet to 172.16.172.53 (I) QM_IDLE
ISAKMP (0:1): purging node 1671177686
ISAKMP (0:1): incrementing error counter on sa: PEERS_ALIVE_TIMER
ISAKMP (0:1): sending packet to 172.16.172.53 (I) QM_IDLE
ISAKMP (0:1): purging node 1706520344
ISAKMP (0:1): incrementing error counter on sa: PEERS_ALIVE_TIMER
ISAKMP (0:1): sending packet to 172.16.172.53 (I) QM_IDLE
ISAKMP (0:1): purging node 503375209
ISAKMP (0:1): incrementing error counter on sa: PEERS_ALIVE_TIMER
ISAKMP (0:1): sending packet to 172.16.172.53 (I) QM_IDLE
ISAKMP (0:1): purging node 1272270610
ISAKMP (0:1): incrementing error counter on sa: PEERS_ALIVE_TIMER
ISAKMP (0:1): peer not responding!
ISAKMP (0:1): peer does paranoid keepalives.

ISAKMP (0:1): phase 1 going away; let's be paranoid.
ISAKMP (0:1): Bring down phase 2's
ISAKMP (0:1): That phase 1 was the last one of its kind.
   Taking phase 2's with us.
ISAKMP (0:1): peer does paranoid keepalives.

ISAKMP (0:1): deleting SA reason "P1 errcounter exceeded
   (PEERS_ALIVE_TIMER)" state (I)
   QM_IDLE (peer 172.16.172.53) input queue 0
IPSEC(key_engine): got a queue event...
IPSEC(key_engine_delete_sas): rec'd delete notify from ISAKMP
IPSEC(key_engine_delete_sas): delete all SAs shared with 172.16.172.53
IPSEC(delete_sa): deleting SA,
(sa) sa_dest= 172.16.172.69, sa_prot= 50,
sa_spi= 0x44E0B22B(1155576363),
sa_trans= esp-des esp-md5-hmac , sa_conn_id= 2029
IPSEC(delete_sa): deleting SA,
(sa) sa_dest= 172.16.172.53, sa_prot= 50,
sa_spi= 0x5B23F22E(1529082414),
sa_trans= esp-des esp-md5-hmac , sa_conn_id= 2030
ISAKMP (0:1): sending packet to 172.16.172.53 (I) MM_NO_STATE
ISAKMP (0:1): purging node -248155233
ISAKMP (0:1): peer does paranoid keepalives.

IPSEC(key_engine): got a queue event...
IPSEC(key_engine_delete_sas): rec'd delete notify from ISAKMP
IPSEC(key_engine_delete_sas): delete all SAs shared with 172.16.172.53
ISAKMP (0:1): purging node 958118275
```

当Cisco 7204VXR-1主HSRP路由器上发生故障切换时，设备将成为备用路由器。现有ISAKMP和IPSec SA已拆除。Cisco 7204VXR-2辅助HSRP路由器变为活动状态，并通过Cisco VPN 7200建立新的IPSec SA。

debug standby events命**令的输出**显示与HSRP相关的事件。

```
HSRP: Fa0/0 API Software interface going down
HSRP: Fa0/0 API Software interface going down
HSRP: Fa0/0 Interface down
HSRP: Fa0/0 Grp 1 Active: b/HSRP disabled
HSRP: Fa0/0 Grp 1 Active router is unknown, was local
HSRP: Fa0/0 Grp 1 Standby router is unknown, was 172.16.172.54
HSRP: Fa0/0 Grp 1 Active -> Init
%HSRP-6-STATECHANGE: FastEthernet0/0 Grp 1 state Active -> Init
HSRP: Fa0/0 Grp 1 Redundancy "VPNHA" state Active -> Init
%CRYPTO-5-SESSION_STATUS: Crypto tunnel is DOWN.
   Peer 172.16.172.69:500 Id: 172.16.172.69
HSRP: Fa0/0 Grp 1 Redundancy enquiry for VPNHA succeeded
HSRP: Fa0/0 API Add active HSRP addresses to ARP table
%LINK-5-CHANGED: Interface FastEthernet0/0,
   changed state to administratively down
HSRP: API Hardware state change
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0,
   changed state to down
```

由于接口关闭，HSRP状态将更改为“Init”。

```
paal#show standby
FastEthernet0/0 - Group 1
State is Init (interface down)
3 state changes, last state change 00:07:29
Virtual IP address is 172.16.172.53
Active virtual MAC address is unknown
Local virtual MAC address is 0000.0c07.ac01 (v1 default)
Hello time 3 sec, hold time 10 sec
Preemption enabled
Active router is unknown
Standby router is unknown
Priority 200 (configured 200)
Track interface FastEthernet0/1 state Up decrement 150
IP redundancy name is "VPNHA" (cfgd)
```

Cisco 7204VXR-2成为活动HSRP路由器，并将其状态更改为“活动”。

```
HSRP: Fa0/0 Grp 1 Standby: c/Active timer expired (172.16.172.52)
HSRP: Fa0/0 Grp 1 Active router is local, was 172.16.172.52
HSRP: Fa0/0 Grp 1 Standby router is unknown, was local
HSRP: Fa0/0 Grp 1 Standby -> Active (active 0->1, passive 2->1)
%HSRP-6-STATECHANGE: FastEthernet0/0 Grp 1 state Standby -> Active
HSRP: Fa0/0 Grp 1 Redundancy "VPNHA" state Standby -> Active
!--- VPN route 20.1.1.0/24 is added to the routing table. IPSEC(rte_mgr): VPN Route Added
20.1.1.0 255.255.255.0 via 172.16.172.69 in IP DEFAULT TABLE 7204VXR-2#show standby
FastEthernet0/0 - Group 1
State is Active
2 state changes, last state change 00:10:38
Virtual IP address is 172.16.172.53
Active virtual MAC address is 0000.0c07.ac01
Local virtual MAC address is 0000.0c07.ac01 (v1 default)
Hello time 3 sec, hold time 10 sec
Next hello sent in 0.116 secs
```

```
Preemption enabled
Active router is local
Standby router is unknown
Priority 100 (default 100)
Track interface FastEthernet1/0 state Up decrement 10
IP redundancy name is "VPNHA" (cfgd)
```

启用RRI后，VPN路由会在故障切换期间动态更新。删除静态路由20.1.1.0/24,Cisco 7204VXR-1路由器从Cisco 7204VXR-2路由器获取该路由。

show ip route命令**的输出**演示了此动态更新。

```
7204VXR-1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF,
       IA - OSPF inter area, N1 - OSPF NSSA external type 1,
       N2 - OSPF NSSA external type 2, E1 - OSPF external type 1,
       E2 - OSPF external type 2, i - IS-IS, su - IS-IS summary,
       L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
       * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

99.0.0.0/32 is subnetted, 1 subnets
O  99.99.99.99 [110/2] via 10.1.1.3, 02:46:16, FastEthernet0/1
20.0.0.0/24 is subnetted, 1 subnets
O E2  20.1.1.0 [110/20] via 10.1.1.2, 00:08:35, FastEthernet0/1
172.16.0.0/28 is subnetted, 1 subnets
O E2  172.16.172.64 [110/20] via 10.1.1.2, 00:07:56, FastEthernet0/1
10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C 10.1.1.0/24 is directly connected, FastEthernet0/1
S  10.48.66.0/23 [1/0] via 10.1.1.2
```

静态VPN路由会注入到Cisco 7204VXR-2路由器的路由表中。

```
7204VXR-2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF,
       IA - OSPF inter area, N1 - OSPF NSSA external type 1,
       N2 - OSPF NSSA external type 2, E1 - OSPF external type 1,
       E2 - OSPF external type 2, i - IS-IS, su - IS-IS summary,
       L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
       * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

99.0.0.0/32 is subnetted, 1 subnets
O  99.99.99.99 [110/2] via 10.1.1.3, 03:04:18, FastEthernet1/0
20.0.0.0/24 is subnetted, 1 subnets
S  20.1.1.0 [1/0] via 172.16.172.69
172.16.0.0/28 is subnetted, 2 subnets
C  172.16.172.48 is directly connected, FastEthernet0/0
S  172.16.172.64 [1/0] via 172.16.172.49
10.0.0.0/24 is subnetted, 1 subnets
C  10.1.1.0 is directly connected, FastEthernet1/0
```

内部路由器7206-1从其OSPF邻居路由器7204VXR-2获知到远程VPN对等体的20.1.1/24路由。这些路由更改通过HSRP/RRI和OSPF的组合动态发生。

```
7206-1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF,
       IA - OSPF inter area, N1 - OSPF NSSA external type 1,
       N2 - OSPF NSSA external type 2, E1 - OSPF external type 1,
       E2 - OSPF external type 2, i - IS-IS, su - IS-IS summary,
       L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
       * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

    99.0.0.0/32 is subnetted, 1 subnets
C     99.99.99.99 is directly connected, Loopback0
    20.0.0.0/24 is subnetted, 1 subnets
O E2     20.1.1.0 [110/20] via 10.1.1.2, 00:13:55, FastEthernet0/1
    172.16.0.0/28 is subnetted, 1 subnets
O E2     172.16.172.64 [110/20] via 10.1.1.2, 00:13:17, FastEthernet0/1
    10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C     10.1.1.0/24 is directly connected, FastEthernet0/1
O E2     10.48.66.0/23 [110/20] via 10.1.1.2, 03:06:08, FastEthernet0/1
```

在HSRP故障切换期间，Cisco 7204VXR-2成为主用路由器后，Cisco 7204VXR-2和Cisco VPN 7200路由器之间的VPN流量将启用ISAKMP和IPSec SA。

VPN 7200路由器上的**show crypto isakmp sa**和**show crypto ipsec sa**命令的输出如下所示：

```
7204VXR-2#show crypto isakmp sa detail
Codes: C - IKE configuration mode, D - Dead Peer Detection
K - Keepalives, N - NAT-traversal
X - IKE Extended Authentication
psk - Preshared key, rsig - RSA signature
renc - RSA encryption

C-id Local        Remote      I-VRF Encr Hash Auth DH Lifetime Cap.
1   172.16.172.53  172.16.172.69        des  md5   psk  1  23:53:47 K
Connection-id:Engine-id = 1:1(software)


7204VXR-2#show crypto ipsec sa

interface: FastEthernet0/0
Crypto map tag: vpn, local addr. 172.16.172.53


protected vrf:
local ident (addr/mask/prot/port): (99.99.99.99/255.255.255.255/0/0)
remote ident (addr/mask/prot/port): (20.1.1.0/255.255.255.0/0/0)
current_peer: 172.16.172.69:500
PERMIT, flags={origin_is_acl,}
#pkts encaps: 9, #pkts encrypt: 9, #pkts digest: 9
#pkts decaps: 9, #pkts decrypt: 9, #pkts verify: 9
#pkts compressed: 0, #pkts decompressed: 0
#pkts not compressed: 0, #pkts compr. failed: 0
#pkts not decompressed: 0, #pkts decompress failed: 0
#send errors 0, #recv errors 0

local crypto endpt.: 172.16.172.53, remote crypto endpt.: 172.16.172.69
path mtu 1500, media mtu 1500
current outbound spi: 83827275

inbound esp sas:
```

```
spi: 0x8D70E8A3(2372987043)
transform: esp-des esp-md5-hmac ,
in use settings ={Tunnel, }
slot: 0, conn id: 2000, flow_id: 1, crypto map: vpn
crypto engine type: Software, engine_id: 1
sa timing: remaining key lifetime (k/sec): (4453897/3162)
ike_cookies: 95074F89 3FF73F2B F70FEDF6 5998090C
IV size: 8 bytes
replay detection support: Y

inbound ah sas:

inbound pcp sas:

outbound esp sas:
spi: 0x83827275(2206364277)
transform: esp-des esp-md5-hmac ,
in use settings ={Tunnel, }
slot: 0, conn id: 2001, flow_id: 2, crypto map: vpn
crypto engine type: Software, engine_id: 1
sa timing: remaining key lifetime (k/sec): (4453898/3162)
ike_cookies: 95074F89 3FF73F2B F70FEDF6 5998090C
IV size: 8 bytes
replay detection support: Y

outbound ah sas:

outbound pcp sas: vpn7200#show crypto isa sa
dst src state conn-id slot
172.16.172.53   172.16.172.69   QM_IDLE 1       0

vpn7200#show crypto ipsec sa

interface: FastEthernet0/1
Crypto map tag: vpn, local addr. 172.16.172.69


local ident (addr/mask/prot/port): (20.1.1.0/255.255.255.0/0/0)
remote ident (addr/mask/prot/port): (99.99.99.99/255.255.255.255/0/0)
current_peer: 172.16.172.53
PERMIT, flags={origin_is_acl,}
#pkts encaps: 19, #pkts encrypt: 19, #pkts digest 19
#pkts decaps: 19, #pkts decrypt: 19, #pkts verify 19
#pkts compressed: 0, #pkts decompressed: 0
#pkts not compressed: 0, #pkts compr. failed: 0, #pkts decompress failed: 0
#send errors 6, #recv errors 0

local crypto endpt.: 172.16.172.69, remote crypto endpt.: 172.16.172.53
path mtu 1500, ip mtu 1500
current outbound spi: 8D70E8A3

inbound esp sas:
spi: 0x83827275(2206364277)
transform: esp-des esp-md5-hmac ,
in use settings ={Tunnel, }
slot: 0, conn id: 2029, flow_id: 1, crypto map: vpn
sa timing: remaining key lifetime (k/sec): (4607997/3070)
IV size: 8 bytes
replay detection support: Y

inbound ah sas:

inbound pcp sas:
```

```
outbound esp sas:
spi: 0x8D70E8A3(2372987043)
transform: esp-des esp-md5-hmac ,
in use settings ={Tunnel, }
slot: 0, conn id: 2030, flow_id: 2, crypto map: vpn
sa timing: remaining key lifetime (k/sec): (4607998/3070)
IV size: 8 bytes
replay detection support: Y

outbound ah sas:

outbound pcp sas:
```

在最初的 HSRP 主路由器从停机中恢复之后

在Cisco 7204VXR-1原始HSRP主路由器上恢复服务后，设备将恢复作为活动路由器的位置，因为它具有更高的优先级，并且已配置HSRP抢占。

来自不同路由器的**show** 和**debug** 命令输出显示了HSRP和IPSec的另一次切换。ISAKMP和IPSec SA会自动重新建立，路由信息更改会动态更新。

此输出示例显示路由器7204VXR-1将其状态更改为“活动”。

```
HSRP: Fa0/0 API 172.16.172.52 is not an HSRP address
HSRP: Fa0/0 API MAC address update
HSRP: Fa0/0 API Software interface coming up
%LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
HSRP: API Hardware state change
HSRP: Fa0/0 API Software interface coming up
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0,
   changed state to up
HSRP: Fa0/0 Interface up
HSRP: Fa0/0 Starting minimum interface delay (1 secs)
HSRP: Fa0/0 Interface min delay expired
HSRP: Fa0/0 Grp 1 Init: a/HSRP enabled
HSRP: Fa0/0 Grp 1 Init -> Listen
HSRP: Fa0/0 Grp 1 Redundancy "VPNHA" state Init -> Backup
HSRP: Fa0/0 Grp 1 Listen: c/Active timer expired (unknown)
HSRP: Fa0/0 Grp 1 Listen -> Speak
HSRP: Fa0/0 Grp 1 Redundancy "VPNHA" state Backup -> Speak
HSRP: Fa0/0 Grp 1 Speak: d/Standby timer expired (unknown)
HSRP: Fa0/0 Grp 1 Standby router is local
HSRP: Fa0/0 Grp 1 Speak -> Standby
HSRP: Fa0/0 Grp 1 Redundancy "VPNHA" state Speak -> Standby
HSRP: Fa0/0 Grp 1 Redundancy enquiry for VPNHA succeeded
HSRP: Fa0/0 Grp 1 Standby: c/Active timer expired (unknown)
HSRP: Fa0/0 Grp 1 Active router is local
HSRP: Fa0/0 Grp 1 Standby router is unknown, was local
HSRP: Fa0/0 Grp 1 Standby -> Active
%HSRP-6-STATECHANGE: FastEthernet0/0 Grp 1 state Standby -> Active
HSRP: Fa0/0 Grp 1 Redundancy "VPNHA" state Standby -> Active
HSRP: Fa0/0 Grp 1 Active: i/Resign rcvd (100/172.16.172.54)
HSRP: Fa0/0 Grp 1 Redundancy group VPNHA state Active -> Active
HSRP: Fa0/0 Grp 1 Redundancy group VPNHA state Active -> Active
HSRP: Fa0/0 Grp 1 Standby router is 172.16.172.54
```

路由器7204VXR-2将其状态更改为“备用”。 VPN路由会从路由表中删除。

```
HSRP: Fa0/0 Grp 1 Standby router is 172.16.172.52
HSRP: Fa0/0 Grp 1 Hello in 172.16.172.52 Active pri 200 vIP 172.16.172.53
```

```
hel 3000 hol 10000 id 0000.0c07.ac01
HSRP: Fa0/0 Grp 1 Active router is 172.16.172.52, was local
HSRP: Fa0/0 Grp 1 Standby router is unknown, was 172.16.172.52
HSRP: Fa0/0 Grp 1 Active: g/Hello rcvd from
   higher pri Active router (200/172.16.172.52)
HSRP: Fa0/0 Grp 1 Active -> Speak (active 1->0, passive 0->1)
%HSRP-6-STATECHANGE: FastEthernet0/0 Grp 1 state Active -> Speak
HSRP: Fa0/0 Grp 1 Redundancy "VPNHA" state Active -> Speak
HSRP: Fa0/0 Grp 1 Speak: d/Standby timer expired (unknown)
HSRP: Fa0/0 Grp 1 Standby router is local
HSRP: Fa0/0 Grp 1 Speak -> Standby (active 0, passive 1)
HSRP: Fa0/0 Grp 1 Redundancy "VPNHA" state Speak -> Standby
HSRP: Fa0/0 Grp 1 Redundancy enquiry for VPNHA succeeded
addr 172.16.172.53 name VPNHA state Speak
active 172.16.172.52 standby 172.16.172.54
 !--- The VPN route is removed. IPSEC(rte_mgr): VPN Route Removed 20.1.1.0 255.255.255.0 via
172.16.172.69 in IP DEFAULT TABLE
```

相关信息

- IPsec 协商/IKE 协议支持页
- 技术支持和文档 - Cisco Systems