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ECE 407

ECE 407

Introduction to Computer Networks Laboratory

Practice 10 – Virtual Private Network

Objectives

The goal of this experiment is to:

1. Familiarize students with IPsec VPN settings.
2. Familiarize students with Test IPsec VPN operation.

Background[1]

VPNs can provide a secure method of transmitting data over a public network, such as the Internet. VPN connections can help reduce the costs associated with leased lines. Site-to-Site VPNs typically provide a secure (IPsec or other) tunnel between a branch office and a central office. Another common implementation of VPN technology is remote access to a corporate office from a telecommuter location, such as a small office or home office.

In this lab, you will build and configure a multi-router network, use Cisco IOS to configure a site-to-site IPsec VPN, and then test the VPN. The IPsec VPN tunnel is from R1 to R3 via R2. R2 acts as a pass-through and has no knowledge of the VPN. IPsec provides secure transmission of sensitive information over unprotected networks, such as the Internet. IPsec acts at the network layer and protecting and authenticating IP packets between participating IPsec devices (peers), such as Cisco routers.

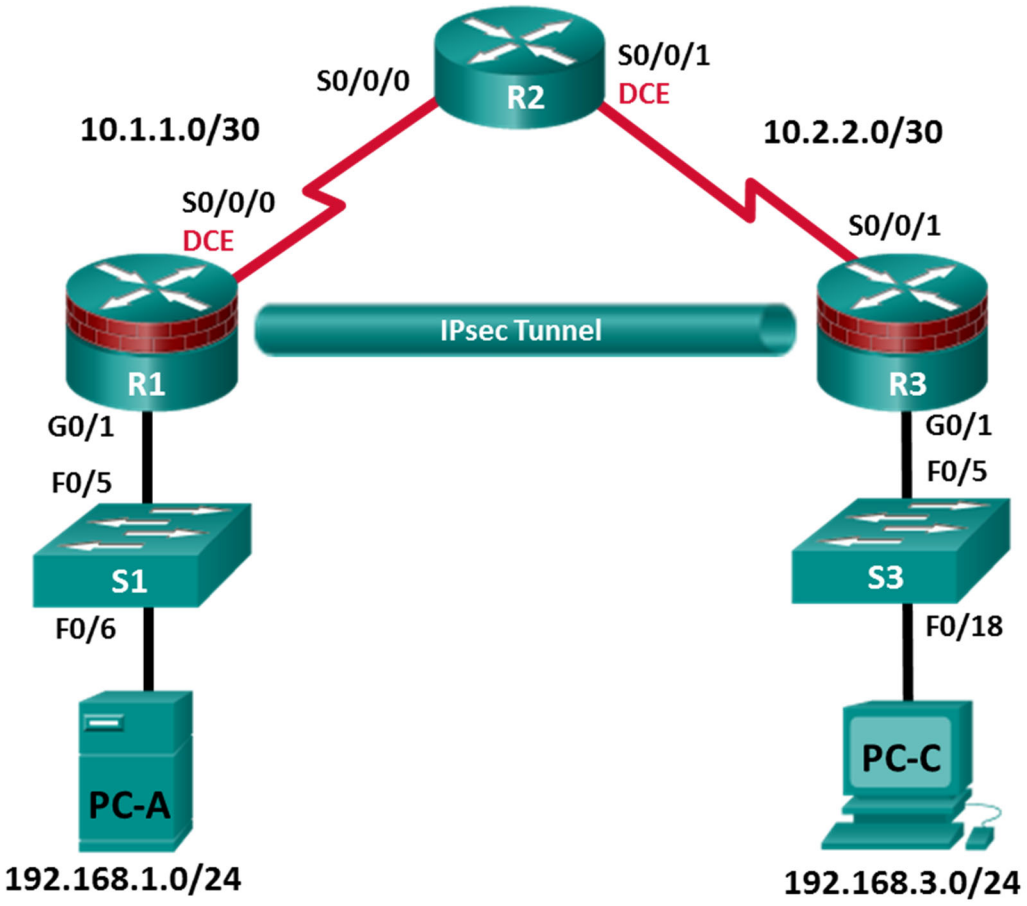
Note: The router commands and output in this lab are from a Cisco 1941 router with Cisco IOS Release 15.4(3)M2 (with a Security Technology Package license). Other routers and Cisco IOS versions can be used. See the Router Interface Summary Table at the end of the lab to determine which interface identifiers to use based on the equipment in the lab. Depending on the router model and Cisco IOS version, the commands available and output produced might vary from what is shown in this lab.

Note: Before beginning, ensure that the routers and the switches have been erased and have no startup configurations.

[1] Source: http://ictechnotes.blogspot.com/2011/07/acls.html

Exercise 1: Configuring a Site-to-Site VPN Using Cisco IOS (8.4.1.3)

Topology



Note: ISR G1 devices use FastEthernet interfaces instead of GigabitEthernet interfaces.

IP Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway	Switch Port
R1	G0/1	192.168.1.1	255.255.255.0	N/A	S1 F0/5
	S0/0/0 (DCE)	10.1.1.1	255.255.255.252	N/A	N/A

R2	S0/0/0	10.1.1.2	255.255.255.252	N/A	N/A
	S0/0/1 (DCE)	10.2.2.2	255.255.255.252	N/A	N/A
R3	G0/1	192.168.3.1	255.255.255.0	N/A	S3 F0/5
	S0/0/1	10.2.2.1	255.255.255.252	N/A	N/A
PC-A	NIC	192.168.1.3	255.255.255.0	192.168.1.1	S1 F0/6
PC-C	NIC	192.168.3.3	255.255.255.0	192.168.3.1	S3 F0/18

Required Resources

- 3 routers (Cisco 1941 with Cisco IOS Release 15.4(3)M2 image with a Security Technology package license)
- 2 switches (Cisco 2960 or comparable) (not required)
- 2 PCs (Windows 7 or Windows 8.1, SSH Client, and WinRadius)
- Serial and Ethernet cables, as shown in the topology
- Console cables to configure Cisco networking devices

Part 1: Basic Device Settings

In Part 1, you will set up the network topology and configure basic settings, such as the interface IP addresses, dynamic routing, device access, and passwords.

Note: All tasks should be performed on R1, R2, and R3. The procedure for R1 is shown here as an example.

Step 1: Cable the Configure network as shown in the topology.

Attach the devices as shown in the topology diagram and cable as necessary.

Step 2: **Configure basic settings for each router.**

a. Configure hostnames, as shown in the topology.

b. Configure the interface IP addresses, as shown in the IP Addressing Table.

c. Configure a clock rate of 64000 for the serial router interfaces with a DCE serial cable attached.

Step 3: **Disable DNS lookup.**

Disable DNS lookup to prevent the router from attempting to translate incorrectly entered commands.

Step 4: **Configure the OSPF routing protocol on R1, R2, and R3.**

a. On R1, use the following commands:

R1(config)# **router ospf 101**
R1(config-router)# **network 192.168.1.0 0.0.0.255 area 0**
R1(config-router)# **network 10.1.1.0 0.0.0.3 area 0**

b. On R2, use the following commands:

R2(config)# **router ospf 101**
R2(config-router)# **network 10.1.1.0 0.0.0.3 area 0**
R2(config-router)# **network 10.2.2.0 0.0.0.3 area 0**

c. On R3, use the following commands:

R3(config)# **router ospf 101**
R3(config-router)# **network 192.168.3.0 0.0.0.255 area 0**
R3(config-router)# **network 10.2.2.0 0.0.0.3 area 0**

Step 5: Configure PC host IP settings.

a. Configure a static IP address, subnet mask, and default gateway for PC-A, as shown in the IP Addressing Table.

b. Configure a static IP address, subnet mask, and default gateway for PC-C, as shown in the IP Addressing Table.

Step 6: Verify basic network connectivity.

a. Ping from R1 to the R3 Fa0/1 interface at IP address 192.168.3.1.

If the pings are unsuccessful, troubleshoot the basic device configurations before continuing.

b. Ping from PC-A on the R1 LAN to PC-C on the R3 LAN.

If the pings are unsuccessful, troubleshoot the basic device configurations before continuing.

Note: If you can ping from PC-A to PC-C, you have demonstrated that the OSPF routing protocol is configured and functioning correctly. If you cannot ping, but the device interfaces are up and IP addresses are correct, use the **show run** and **show ip route** commands to help identify routing protocol-related problems.

Step 1: Configure and encrypt passwords.

Note: Passwords in this task are set to a minimum of 10 characters but are relatively simple for the benefit of performing the lab. More complex passwords are recommended in a production network.

Configure the same settings for R1 and R3. R1 is shown here as an example.

a. Configure a minimum password length.

Use the **security passwords** command to set a minimum password length of 10 characters.

b. Configure the enable secret password on both routers with a password of **cisco12345**. Use the type 9 (SCRYPT) hashing algorithm.

c. Create a local **admin01** account using **admin01pass** for the password. Use the type 9 (SCRYPT) hashing algorithm.

Step 7: **Configure the console line.**

Configure the console to use the local database for login. For additional security, configure the line to log out after five minutes of inactivity. Issue the **logging synchronous** command to prevent console messages from interrupting command entry.

Step 8: **Configure SSH Server.**

a. Configure a domain name **ccnasecurity.com**.

b. Configure the RSA keys with **1024** for the number of modulus bits.

c. Issue the command to force the use of SSH version 2.

d. Configure the vty lines on R1 and R3 to use the local database for login. Remote access to the routers should only be allowed using SSH. Configure the vty lines to logout after five minutes of inactivity.

Step 9:Save the basic running configuration for all three routers.

Save the running configuration to the startup configuration from the privileged EXEC mode prompt on R1, R2, and R3.

R1# **copy running-config startup-config**

Part 2:Configure a Site-to-Site VPN with Cisco IOS

In Part 2 of this lab, you will configure an IPsec VPN tunnel between R1 and R3 that passes through R2. You will configure R1 and R3 using the Cisco IOS CLI. You will then review and test the resulting configuration.

Task 1: Configure IPsec VPN Settings on R1 and R3.

Step 1: **Verify connectivity from the R1 LAN to the R3 LAN.**

In this task, you will verify that PC-A on the R1 LAN can ping PC-C on the R3 LAN with no tunnel in place.

Ping the PC-C IP address of **192.168.3.3** from PC-A.

PC-A:\> **ping 192.168.3.3**

If the pings are unsuccessful, troubleshoot the basic device configurations before continuing.

Step 2: **Enable IKE policies on R1 and R3.**

IPsec is an open framework that allows for the exchange of security protocols as new technologies, and encryption algorithms as they are developed.

There are two central configuration elements in the implementation of an IPsec VPN:

- Implement Internet Key Exchange (IKE) parameters
- Implement IPsec parameters

a. Verify that IKE is supported and enabled.

IKE Phase 1 defines the key exchange method used to pass and validate IKE policies between peers. In IKE Phase 2, the peers exchange and match IPsec policies for the authentication and encryption of data traffic.

IKE must be enabled for IPsec to function. IKE is enabled, by default, on IOS images with cryptographic feature sets. If it is disabled, you can enable it with the **crypto isakmp enable** command. Use this command to verify that the router IOS supports IKE and that it is enabled.

R1(config)# **crypto isakmp enable**

R3(config)# **crypto isakmp enable**

Note: If you cannot execute this command on the router, you must upgrade to the IOS image that includes the Cisco cryptographic services.

b. Establish an ISAKMP policy and view the available options.

To allow IKE Phase 1 negotiation, you must create an ISAKMP policy and configure a peer association involving that ISAKMP policy. An ISAKMP policy defines the authentication and encryption algorithms and the hash function used to send control traffic between the two VPN endpoints. When an ISAKMP security association has been accepted by the IKE peers, IKE Phase 1 has been completed. IKE Phase 2 parameters will be configured later.

Issue the **crypto isakmp policy number** global configuration mode command on R1 for policy 10.

R1(config)# **crypto isakmp policy 10**

c. View the various IKE parameters available using Cisco IOS help by typing a question mark (**?**).

```
R1(config-isakmp)# ?
ISAKMP commands:
  authentication  Set authentication method for protection suite
  default         Set a command to its defaults
  encryption      Set encryption algorithm for protection suite
  exit            Exit from ISAKMP protection suite configuration mode
  group           Set the Diffie-Hellman group
  hash            Set hash algorithm for protection suite
  lifetime        Set lifetime for ISAKMP security association
  no              Negate a command or set its defaults
```

Step 3:Configure the IKE Phase 1 ISAKMP policy on R1 and R3.

Your choice of an encryption algorithm determines how confidential the control channel between the endpoints is. The hash algorithm controls data integrity, ensuring that the data received from a peer has not been tampered with in transit. The authentication type ensures that the packet was sent and signed by the remote peer. The Diffie-Hellman group is used to create a secret key shared by the peers that has not been sent across the network.

a. Configure an ISAKMP policy with a priority of **10**. Use **pre-shared key** as the authentication type, **aes 256** for the encryption algorithm, **sha** as the hash algorithm, and the Diffie-Hellman group **14** key exchange. Give the policy a lifetime of **3600** seconds (one hour).

Note: Older versions of Cisco IOS do not support AES 256 encryption and SHA as a hash algorithm. Substitute whatever encryption and hashing algorithm your router supports. Ensure that the same changes are made on R3 in order to be in sync.

R1(config)# **crypto isakmp policy 10**
R1(config-isakmp)# **hash sha**
R1(config-isakmp)# **authentication pre-share**
R1(config-isakmp)# **group 14**
R1(config-isakmp)# **lifetime 3600**
R1(config-isakmp)# **encryption aes 256**
R1(config-isakmp)# **end**

b. Configure the same policy on R3.

R3(config)# **crypto isakmp policy 10**
R3(config-isakmp)# **hash sha**
R3(config-isakmp)# **authentication pre-share**
R3(config-isakmp)# **group 14**
R3(config-isakmp)# **lifetime 3600**
R3(config-isakmp)# **encryption aes 256**
R3(config-isakmp)# **end**

c. Verify the IKE policy with the **show crypto isakmp policy** command.

R1# **show crypto isakmp policy**
Global IKE policy
Protection suite of priority 10
encryption algorithm: AES - Advanced Encryption Standard (256 bit keys).
hash algorithm: Secure Hash Standard
authentication method: Pre-Shared Key
Diffie-Hellman group: #14 (2048 bit)
lifetime: 3600 seconds, no volume limit

Step 4:Configure pre-shared keys.

Because pre-shared keys are used as the authentication method in the IKE policy, a key must be configured on each router that points to the other VPN endpoint. These keys must match for authentication to be successful. The global configuration mode **crypto isakmp key <key-string> address <ip-address>** command is used to enter a pre-shared key. Use the IP address of the remote peer, which is the remote interface that the peer would use to route traffic to the local router.

Which IP addresses should you use to configure the IKE peers, given the topology diagram and IP addressing table?

They should be R1 S0/0/0 with IP 10.1.1.1 and R3 S0/0/1 with IP 10.2.2.1 which are the addresses that are used for normal traffic of R1 and R3.

a. Each IP address that is used to configure the IKE peers is also referred to as the IP address of the remote VPN endpoint. Configure the pre-shared key of **cisco123** on router R1. Production networks should use a complex key. This command points to the remote peer R3 S0/0/1 IP address.

   R1(config)# **crypto isakmp key cisco123 address 10.2.2.1**

b. Configure the pre-shared key **cisco123** on router R3. The command for R3 points to the R1 S0/0/0 IP address.

   R3(config)# **crypto isakmp key cisco123 address 10.1.1.1**

Step 5: Configure the IPsec transform set and lifetime.

a. The IPsec transform set is another crypto configuration parameter that routers negotiate to form a security association. To create an IPsec transform set, use the **crypto ipsec transform-set <tag>** command. Use **?** to see which parameters are available.

   R1(config)# **crypto ipsec transform-set 50 ?**

   ah-md5-hmac AH-HMAC-MD5 transform
   ah-sha-hmac AH-HMAC-SHA transform
   comp-lzs IP Compression using the LZS compression algorithm
   esp-3des ESP transform using 3DES(EDE) cipher (168 bits)
   esp-aes ESP transform using AES cipher
   esp-des ESP transform using DES cipher (56 bits)
   esp-md5-hmac ESP transform using HMAC-MD5 auth
   esp-null ESP transform w/o cipher
   esp-seal ESP transform using SEAL cipher (160 bits)
   esp-sha-hmac ESP transform using HMAC-SHA auth

b. On R1 and R3, create a transform set with tag 50 and use an ESP transform with an AES 256 cipher with ESP and the SHA hash function. The transform sets must match.

   R1(config)# **crypto ipsec transform-set 50 esp-aes 256 esp-sha-hmac**
   R1(cfg-crypto-trans)# **exit**

   R3(config)# **crypto ipsec transform-set 50 esp-aes 256 esp-sha-hmac**
   R3(cfg-crypto-trans)# **exit**

   What is the function of the IPsec transform set?

   It works on specific cryptographic functions and algorithms which a router will send through the actual data packets in the IPsec tunnel. Those have different methods such as encryption, authentication, data integrity, encapsulation, etc. which may be applied.

c. You can also change the IPsec security association lifetime from the default of 3600 seconds. On R1 and R3, set the IPsec security association lifetime to 30 minutes, or 1800 seconds.

R1(config)# **crypto ipsec security-association lifetime seconds 1800**

R3(config)# **crypto ipsec security-association lifetime seconds 1800**

Step 6: Define interesting traffic.

To make use of the IPsec encryption with the VPN, it is necessary to define extended access lists to tell the router which traffic to encrypt. A packet that is permitted by an access list used for defining IPsec traffic is encrypted if the IPsec session is configured correctly. A packet that is denied by one of these access lists is not dropped it is sent unencrypted. Also, like any other access list, there is an implicit deny at the end, which means the default action is to not encrypt traffic. If there is no IPsec security association correctly configured, no traffic is encrypted and traffic is forwarded unencrypted.

In this scenario, from the perspective of R1, the traffic you want to encrypt is traffic going from R1's Ethernet LAN to R3's Ethernet LAN or vice versa from the perspective of R3. These access lists are used outbound on the VPN endpoint interfaces and must mirror each other.

a. Configure the IPsec VPN interesting traffic ACL on R1.

R1(config)# **access-list 101 permit ip 192.168.1.0 0.0.0.255 192.168.3.0 0.0.0.255**

b. Configure the IPsec VPN interesting traffic ACL on R3.

R3(config)# **access-list 101 permit ip 192.168.3.0 0.0.0.255 192.168.1.0 0.0.0.255**

Does IPsec evaluate whether the access lists are mirrored as a requirement to negotiate its security association?

Yes it checks if they are mirrored. IPsec does not form a security association if the peers do not have mirrored access lists to select traffic.

Step 7: Create and apply a crypto map.

A crypto map associates traffic that matches an access list to a peer and various IKE and IPsec settings. After the crypto map is created, it can be applied to one or more interfaces. The interfaces that it is applied to should be the ones facing the IPsec peer.

To create a crypto map, use **crypto map <name> <sequence-num> <type>** command in global configuration mode to enter crypto map configuration mode for that sequence number. Multiple crypto map statements can belong to the same crypto map and are evaluated in ascending numerical order. Enter crypto map configuration mode on R1. Use a type of ipsec-isakmp, which means IKE is used to establish IPsec security associations.

a. Create the crypto map on R1, name it **CMAP**, and use **10** as the sequence number. A message displays after the command is issued.

R1(config)# **crypto map CMAP 10 ipsec-isakmp**
% NOTE: This new crypto map will remain disabled until a peer
and a valid access list have been configured.

b. Use the **match address <access-list>** command to specify which access list defines which traffic to encrypt.

R1(config-crypto-map)# **match address 101**

c. To view the list of possible **set** commands that you can do with a crypto map, use the help function.

R1(config-crypto-map)# **set ?**

```
  identity            Identity restriction.
  ip                  Interface Internet Protocol config commands
  isakmp-profile      Specify isakmp Profile
  nat                 Set NAT translation
  peer                Allowed Encryption/Decryption peer.
  pfs                 Specify pfs settings
  reverse-route       Reverse Route Injection.
  security-association Security association parameters
  transform-set       Specify list of transform sets in priority order
```

d. Setting a peer IP or hostname is required. Set it to R3's remote VPN endpoint interface using the following command.

R1(config-crypto-map)# **set peer 10.2.2.1**

e. Use the **set transform-set <tag>** command to hard code the transform set to be used with this peer. Set the perfect forwarding secrecy type using the **set pfs <type>** command, and modify the default IPsec security association life time with the **set security-association lifetime seconds <seconds>** command.

R1(config-crypto-map)# **set pfs group14**
R1(config-crypto-map)# **set transform-set 50**
R1(config-crypto-map)# **set security-association lifetime seconds 900**
R1(config-crypto-map)# **exit**

f. Create a mirrored matching crypto map on R3.

R3(config)# **crypto map CMAP 10 ipsec-isakmp**
R3(config-crypto-map)# **match address 101**
R3(config-crypto-map)# **set peer 10.1.1.1**
R3(config-crypto-map)# **set pfs group14**
R3(config-crypto-map)# **set transform-set 50**
R3(config-crypto-map)# **set security-association lifetime seconds 900**
R3(config-crypto-map)# **exit**

g. Apply the crypto map to interfaces.

Note: The SAs are not established until the crypto map has been activated by interesting traffic. The router generates a notification that crypto is now on.

Apply the crypto maps to the appropriate interfaces on R1 and R3.

```
R1(config)# interface S0/0/0
R1(config-if)# crypto map CMAP
*Jan 28 04:09:09.150: %CRYPTO-6-ISAKMP_ON_OFF: ISAKMP is ON
R1(config)# end

R3(config)# interface S0/0/1
R3(config-if)# crypto map CMAP
*Jan 28 04:10:54.138: %CRYPTO-6-ISAKMP_ON_OFF: ISAKMP is ON
R3(config)# end
```

Task 2: **Verify the Site-to-Site IPsec VPN Configuration.**

Step 1: Verify the IPsec configuration on R1 and R3.

a. Previously, you used the **show crypto isakmp policy** command to display the configured ISAKMP policies on the router. The **show crypto ipsec transform-set** command displays the configured IPsec policies in the form of the transform sets.

```
R1# show crypto ipsec transform-set
Transform set 50: { esp-256-aes esp-sha-hmac  }
  will negotiate = { Tunnel,  },

Transform set #$!default_transform_set_1: { esp-aes esp-sha-hmac  }
  will negotiate = { Transport,  },

Transform set #$!default_transform_set_0: { esp-3des esp-sha-hmac  }
  will negotiate = { Transport,  },

R3# show crypto ipsec transform-set
Transform set 50: { esp-256-aes esp-sha-hmac  }
  will negotiate = { Tunnel,  },

Transform set #$!default_transform_set_1: { esp-aes esp-sha-hmac  }
  will negotiate = { Transport,  },

Transform set #$!default_transform_set_0: { esp-3des esp-sha-hmac  }
  will negotiate = { Transport,  },
```

b. Use the **show crypto map** command to display the crypto maps that will be applied to the router.

```
R1# show crypto map
Crypto Map "CMAP" 10 ipsec-isakmp
```

```
    Peer = 10.2.2.1
    Extended IP access list 101
       access-list 101 permit ip 192.168.1.0 0.0.0.255 192.168.3.0 0.0.0.255
    Current peer: 10.2.2.1
    Security association lifetime: 4608000 kilobytes/900 seconds
    Responder-Only (Y/N): N
    PFS (Y/N): Y
    DH group:  group14
    Transform sets={
          50:  { esp-256-aes esp-sha-hmac  } ,
    }
    Interfaces using crypto map CMAP:
          Serial0/0/0

R3# show crypto map
Crypto Map "CMAP" 10 ipsec-isakmp
    Peer = 10.1.1.1
    Extended IP access list 101
       access-list 101 permit ip 192.168.3.0 0.0.0.255 192.168.1.0 0.0.0.255
    Current peer: 10.1.1.1
    Security association lifetime: 4608000 kilobytes/900 seconds
    Responder-Only (Y/N): N
    PFS (Y/N): Y
    DH group:  group14
    Transform sets={
          50:  { esp-256-aes esp-sha-hmac  } ,
    }
    Interfaces using crypto map CMAP:
          Serial0/0/1
```

Note: The output of these **show** commands does not change if interesting traffic goes across the connection. You test various types of traffic in the next task.

Task 3:**Verify the IPsec VPN Operation.**

Step 1:Display ISAKMP security associations.

The **show crypto isakmp sa** command reveals that no IKE SAs exist yet. When interesting traffic is sent, this command output will change.

```
R1# show crypto isakmp sa
IPv4 Crypto ISAKMP SA
```

```
dst             src             state          conn-id status

IPv6 Crypto ISAKMP SA
```

Step 2: Display IPsec security associations.

The **show crypto ipsec sa** command shows the unused SA between R1 and R3.

Note: The number of packets sent across is zero, and there is a lack of any security associations listed toward the bottom of the output. The output for R1 is shown here.

```
R1# show crypto ipsec sa

interface: Serial0/0/0
    Crypto map tag: CMAP, local addr 10.1.1.1

  protected vrf: (none)
  local  ident (addr/mask/prot/port): (192.168.1.0/255.255.255.0/0/0)
  remote ident (addr/mask/prot/port): (192.168.3.0/255.255.255.0/0/0)
  current_peer 10.2.2.1 port 500
    PERMIT, flags={origin_is_acl,}
   #pkts encaps: 0, #pkts encrypt: 0, #pkts digest: 0
   #pkts decaps: 0, #pkts decrypt: 0, #pkts verify: 0
   #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.: 10.1.1.1, remote crypto endpt.: 10.2.2.1
    path mtu 1500, ip mtu 1500, ip mtu idb Serial0/0/0
    current outbound spi: 0x0(0)
    PFS (Y/N): N, DH group: none

    inbound esp sas:

    inbound ah sas:

    inbound pcp sas:

    outbound esp sas:
```

outbound ah sas:

outbound pcp sas:

Why haven't any SAs been negotiated?

The IPsec hasn't negotiated with an SA where data will be encrypted as no interesting traffic has been recognized.

Step 3: Generate some uninteresting test traffic and observe the results.

a. Ping from R1 to the R3 S0/0/1 interface IP address **10.2.2.1**. These pings should be successful.

b. Issue the **show crypto isakmp sa** command.

c. Ping from R1 to the R3 G0/1 interface IP address **192.168.3.1**. These pings should be successful.

d. Issue the **show crypto isakmp sa** command again. Was an SA created for these pings? Explain.

SA is not created. It was not created as the source of the pings was R1 S0/0/0 of IP 10.1.1.1. Within the first case the destination was 10.2.2.1 and in the second it was 192.168.3.1. Although both of these are not interesting traffic. It would have to be traffic from 192.168.1.0/24 or 192.168.3.0/24 to be interesting traffic as seen in the ACL 101 linked to the crypto map of R1.

e. Issue the **debug ip ospf hello** command. You should see OSPF hello packets passing between R1 and R3.

R1# **debug ip ospf hello**

OSPF hello events debugging is on

R1#

*Apr 7 18:04:46.467: OSPF: Send hello to 224.0.0.5 area 0 on GigabitEthernet0/1 from 192.168.1.1

*Apr 7 18:04:50.055: OSPF: Send hello to 224.0.0.5 area 0 on Serial0/0/0 from 10.1.1.1

*Apr 7 18:04:52.463: OSPF: Rcv hello from 10.2.2.2 area 0 from Serial0/0/0 10.1.1.2

*Apr 7 18:04:52.463: OSPF: End of hello processing

*Apr 7 18:04:55.675: OSPF: Send hello to 224.0.0.5 area 0 on GigabitEthernet0/1 from 192.168.1.1

*Apr 7 18:04:59.387: OSPF: Send hello to 224.0.0.5 area 0 on Serial0/0/0 from 10.1.1.1

*Apr 7 18:05:02.431: OSPF: Rcv hello from 10.2.2.2 area 0 from Serial0/0/0 10.1.1.2

*Apr 7 18:05:02.431: OSPF: End of hello processing

f. Turn off debugging with the **no debug ip ospf hello** or **undebug all** command.

g. Re-issue the **show crypto isakmp sa** command. Was an SA created between R1 and R3? Explain.

No it is not created. This is router-to-router protocol and the source and destination of these are not interesting. As they are not interesting the SA does not engage in the encryption.

Step 4: Generate some interesting test traffic and observe the results.

a. Use an extended ping from R1 to the R3 G0/1 interface IP address **192.168.3.1**. Extended ping allows you to control the source address of the packets. Respond as shown in the following example. Press **Enter** to accept the defaults, except where a specific response is indicated.

R1# **ping**
Protocol [ip]:
Target IP address: **192.168.3.1**
Repeat count [5]:
Datagram size [100]:
Timeout in seconds [2]:
Extended commands [n]: **y**
Source address or interface: **192.168.1.1**
Type of service [0]:
Set DF bit in IP header? [no]:
Validate reply data? [no]:
Data pattern [0xABCD]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Sweep range of sizes [n]:
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:

Packet sent with a source address of 192.168.1.1
..!!!
Success rate is 100 percent (3/5), round-trip min/avg/max = 92/92/92 ms

b. Re-issue the **show crypto isakmp sa** command.

R1# **show crypto isakmp sa**
IPv4 Crypto ISAKMP SA
dst src state conn-id status
10.2.2.1 10.1.1.1 QM_IDLE 1001 ACTIVE

IPv6 Crypto ISAKMP SA

Why was an SA created between R1 and R3 this time?

It is because the source was 192.168.1.1 with destination 192.168.3.1. This is interesting traffic as described previously above in the ACL 101. This is what establishes the SA and packets may travel throughout as encrypted traffic

What are the endpoints of the IPsec VPN tunnel?

The Source: 10.1.1.1 (R1 S0/0/0)

The Destination: 10.2.2.1 (R3 S0/0/1)

c. Ping from PC-A to PC-C. If the pings were successful, issue the **show crypto ipsec sa** command. How many packets have been transformed between R1 and R3?

7. 3 of the packets come from R1 to R4 and 4 come from PC-A to R3.

R1# **show crypto ipsec sa**

```
interface: Serial0/0/0
    Crypto map tag: CMAP, local addr 10.1.1.1

  protected vrf: (none)
  local  ident (addr/mask/prot/port): (192.168.1.0/255.255.255.0/0/0)
  remote ident (addr/mask/prot/port): (192.168.3.0/255.255.255.0/0/0)
  current_peer 10.2.2.1 port 500
    PERMIT, flags={origin_is_acl,}
   #pkts encaps: 7, #pkts encrypt: 7, #pkts digest: 7
   #pkts decaps: 7, #pkts decrypt: 7, #pkts verify: 7
   #pkts compressed: 0, #pkts decompressed: 0
   #pkts not compressed: 0, #pkts compr. failed: 0
   #pkts not decompressed: 0, #pkts decompress failed: 0
   #send errors 2, #recv errors 0

    local crypto endpt.: 10.1.1.1, remote crypto endpt.: 10.2.2.1
    path mtu 1500, ip mtu 1500, ip mtu idb Serial0/0/0
    current outbound spi: 0xC1DD058(203280472)

    inbound esp sas:
     spi: 0xDF57120F(3747025423)
       transform: esp-256-aes esp-sha-hmac ,
       in use settings ={Tunnel, }
       conn id: 2005, flow_id: FPGA:5, crypto map: CMAP
       sa timing: remaining key lifetime (k/sec): (4485195/877)
       IV size: 16 bytes
       replay detection support: Y
       Status: ACTIVE

    inbound ah sas:
```

inbound pcp sas:

outbound esp sas:
spi: 0xC1DD058(203280472)
transform: esp-256-aes esp-sha-hmac ,
in use settings ={Tunnel, }
conn id: 2006, flow_id: FPGA:6, crypto map: CMAP
sa timing: remaining key lifetime (k/sec): (4485195/877)
IV size: 16 bytes
replay detection support: Y
Status: ACTIVE

outbound ah sas:

outbound pcp sas:

d. The previous example used pings to generate interesting traffic. What other types of traffic would result in an SA forming and tunnel establishment?

The traffic which comes from R1 with a source of 192.168.1.0/24 and destination of 192.168.3.0/24. From R3, interesting traffic would be considered the opposite which holds the source as 192.168.3.0/24 and destination of 192.168.1.0/24, including HTTP, Telnet, etc.

Reflection

1. Would traffic on the Gigabit Ethernet link between PC-A and the R1 G0/0 interface be encrypted by the site-to-site IPsec VPN tunnel? Explain.

No it would not as this is a site-to-site VPN which only encrypts from router R1 to R3. Although a sniffer may be used to see traffic from PC-A to the R1 default gateway.

Router Interface Summary Table

Router Interface Summary				
Router Model	**Ethernet Interface #1**	**Ethernet Interface #2**	**Serial Interface #1**	**Serial Interface #2**
1800	Fast Ethernet 0/0 (Fa0/0)	Fast Ethernet 0/1 (Fa0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (Fa0/0)	Fast Ethernet 0/1 (Fa0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (Fa0/0)	Fast Ethernet 0/1 (Fa0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. This table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.