CSE 3502

INFORMATION SECURITY MANAGEMENT

Lab Assessment – 4

L19+L20 | SJT516
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by

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Exp 4. VPN Configuration

Introduction to VPN

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.

Objectives

Part 1: Configure Basic Device Settings

- Configure hostnames, interface IP addresses, and access passwords.
- Configure the OSPF dynamic routing protocol.

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

- Configure IPsec VPN settings on R1 and R3.
- Verify site-to-site IPsec VPN configuration.
- Test IPsec VPN operation.

Scenario

In this lab, I 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.

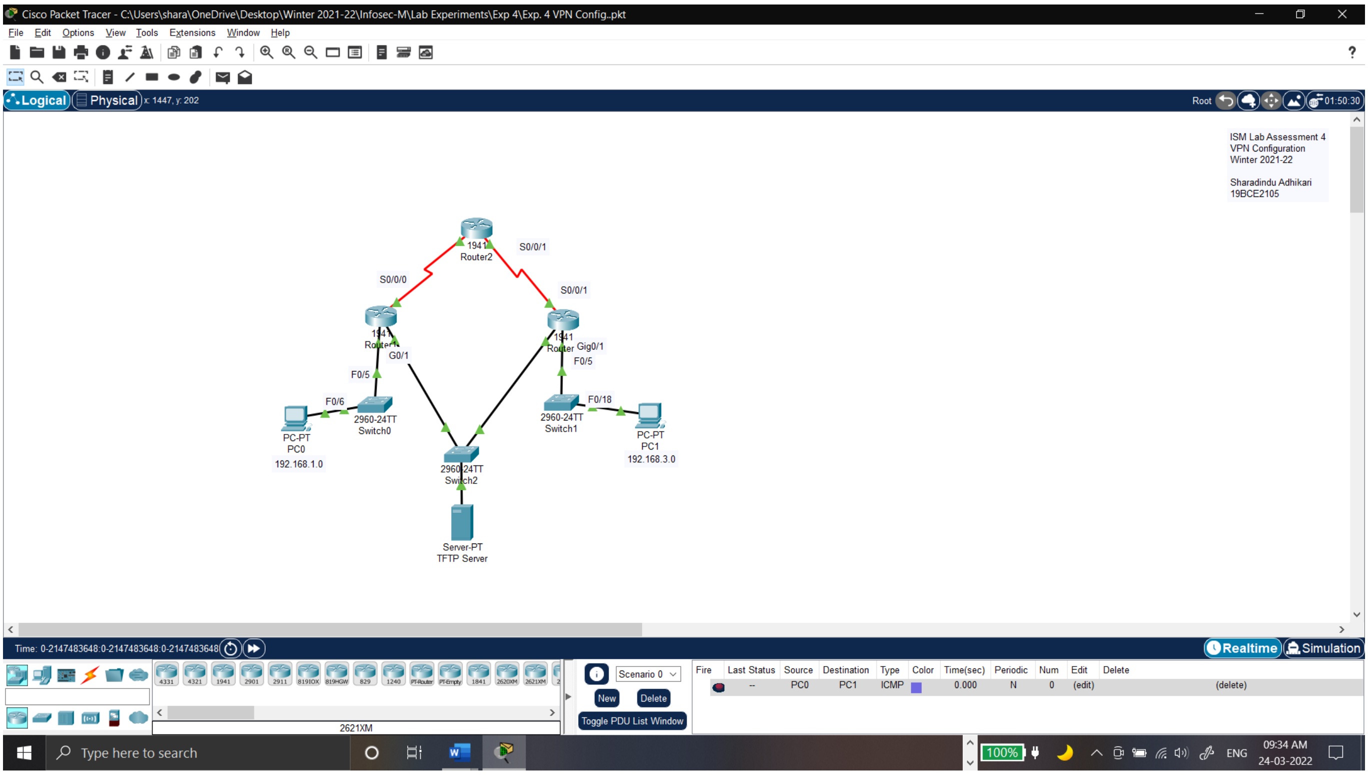
Components

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

- 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

Final Topology Diagram



PART 1: Configure Basic Device Settings

Step 1: Cable the 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.

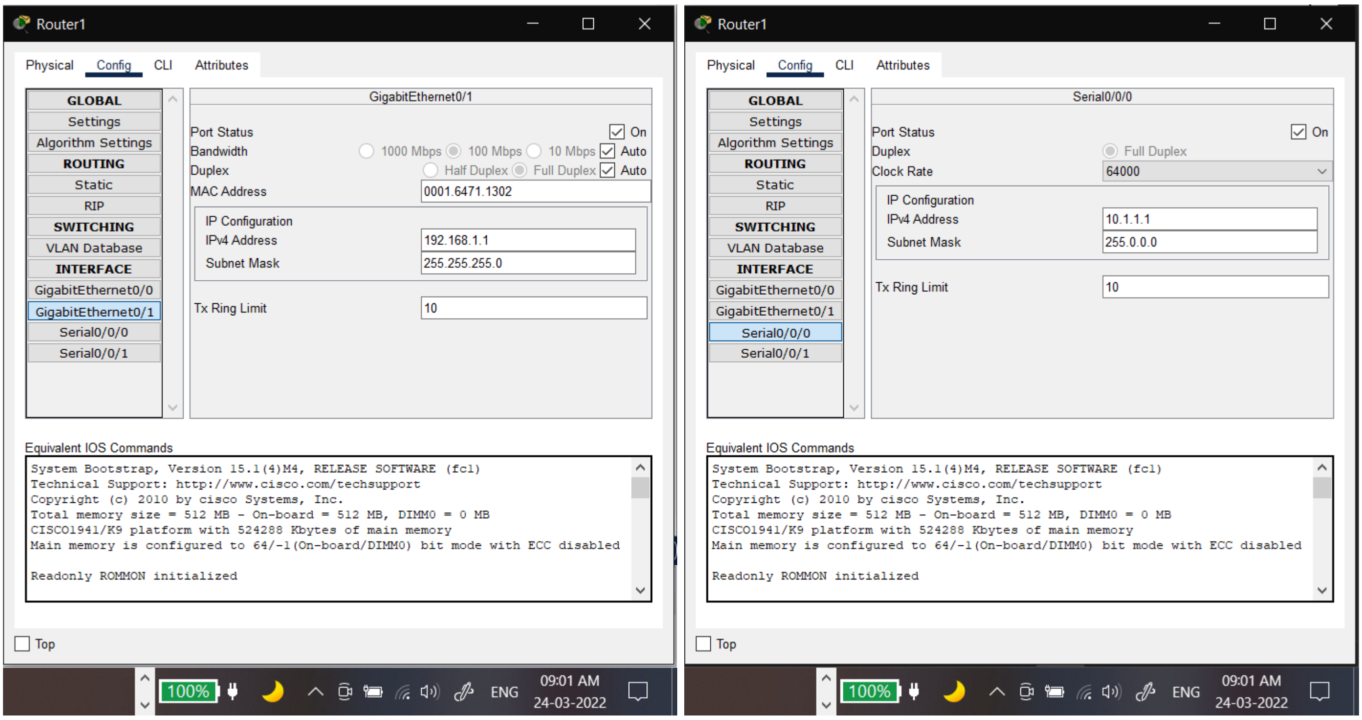
a. Configure hostnames, as shown in the topology.

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.



Figs. Router1 GigabitEthernet0/1; Router1 Serial0/0/0

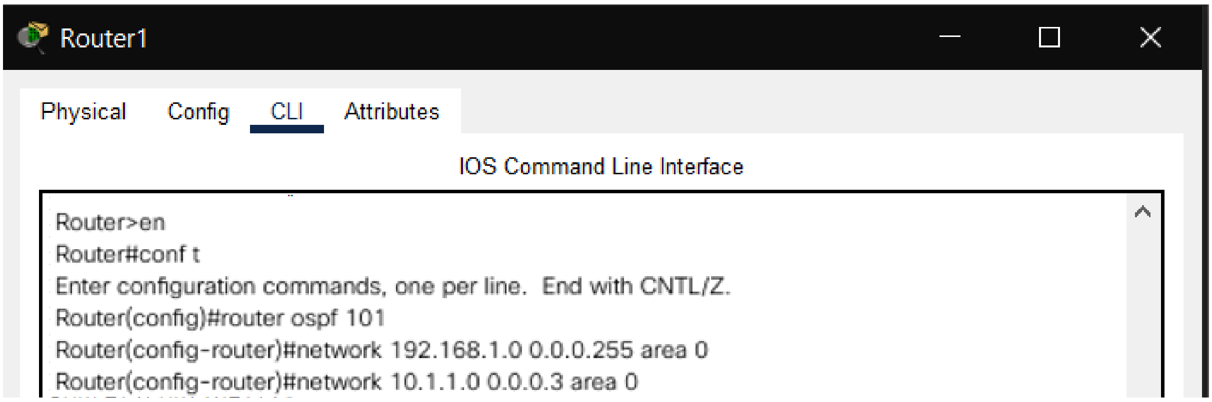
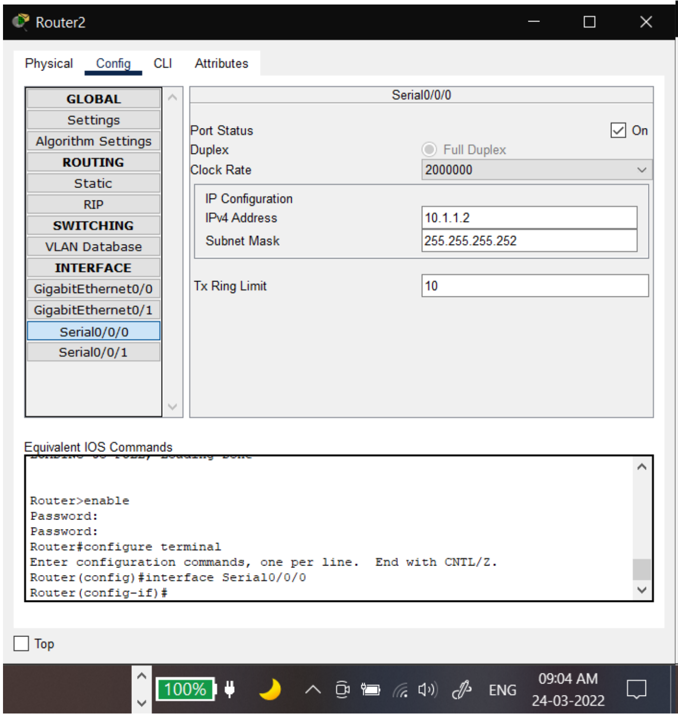
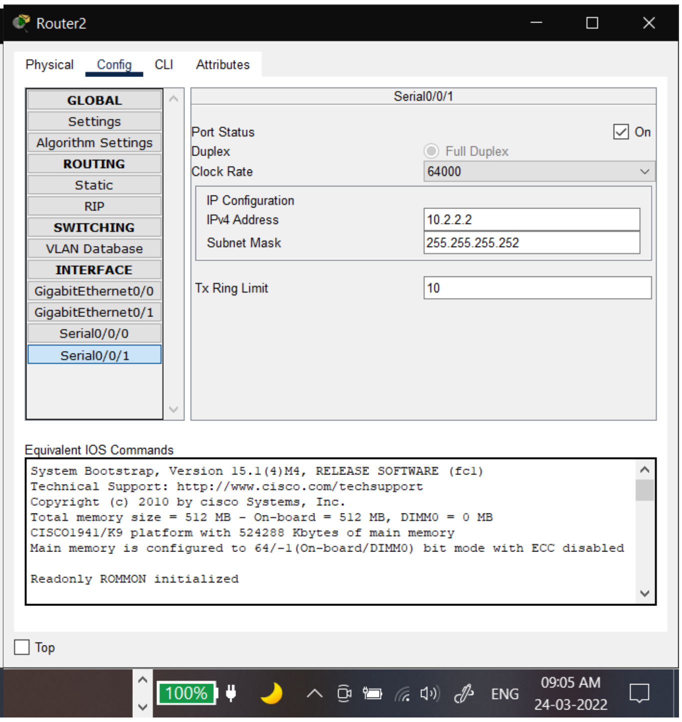


Fig. OSPF Routing in Router1





Figs. Router2 Serial0/0/0; Router2 Serial0/0/1

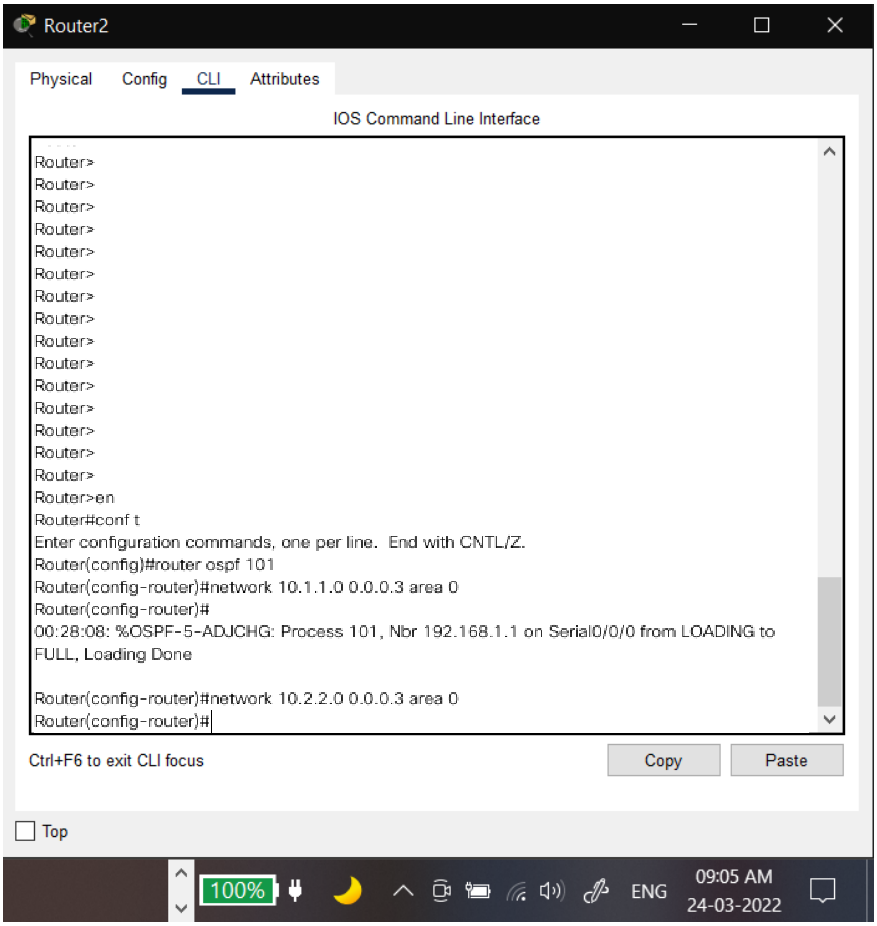
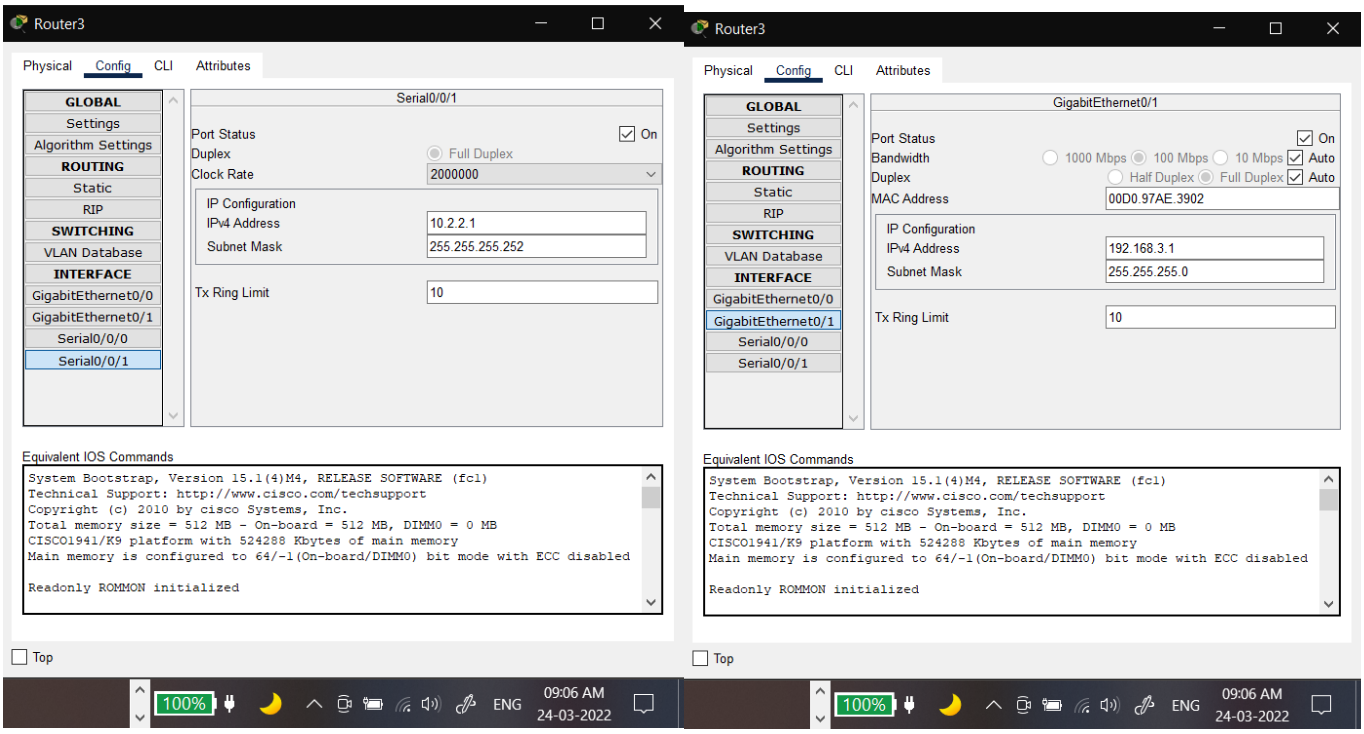


Fig. Router2 OSPF Routing



Figs. Router3 Serial0/0/1; Router3 GigabitEthernet0/1

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.

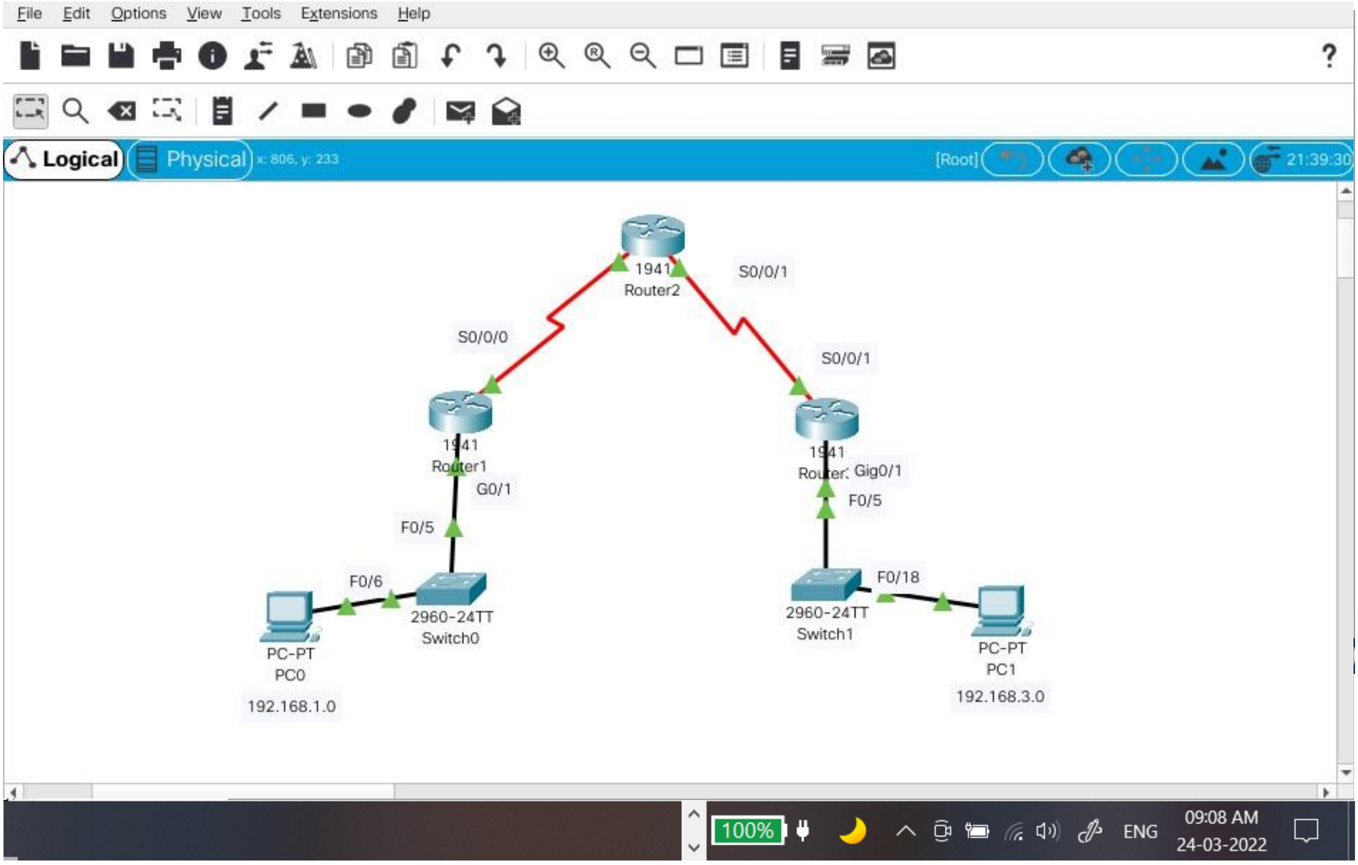


Fig. Connected Network Topology

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num	Edit	Delete
	Successful	PC0	PC1	IC...		0.000	N	0	(e...	(delete)
	Successful	PC1	PC0	IC...		0.000	N	1	(e...	(delete)

Fig. Successful Pings from PC0 to PC1 and vice versa

Step 7: 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.

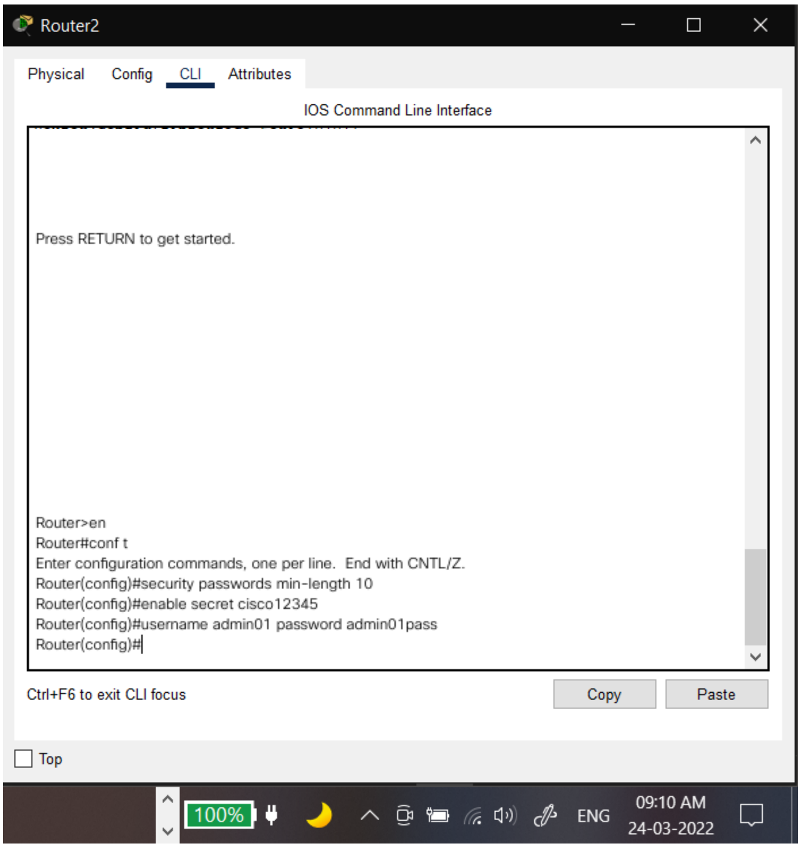


Fig. Configure passwords for Router2

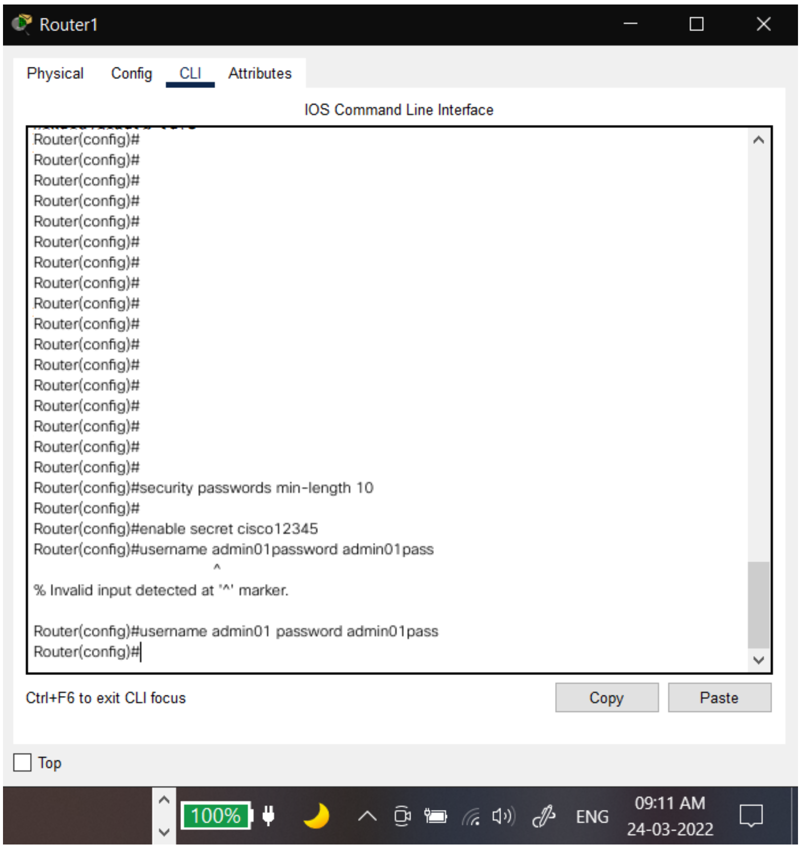


Fig. Configure passwords for Router1

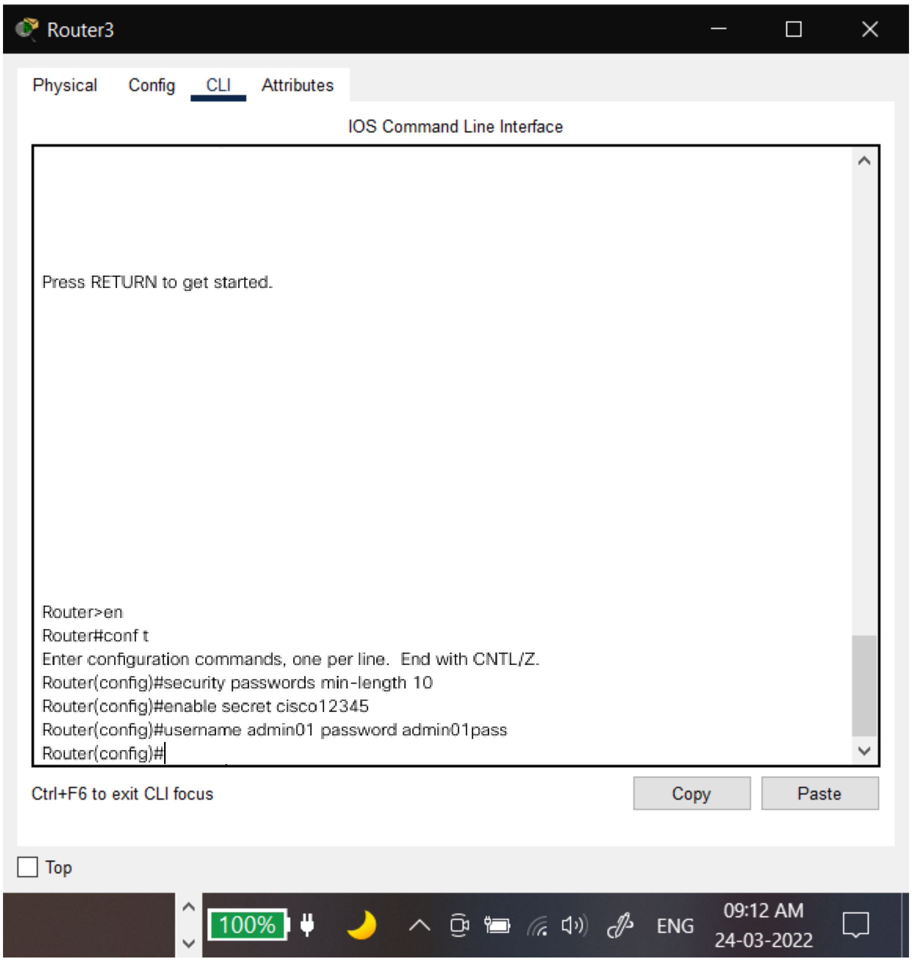


Fig. Configure passwords for Router3

Step 8: 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 9: 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 10: 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
```

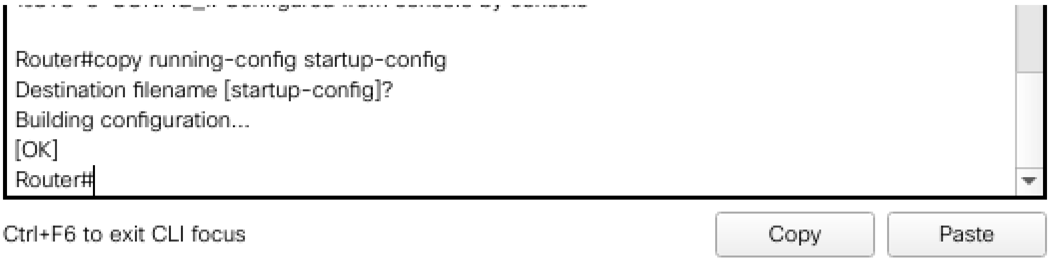


Fig. Saving running config for all routers

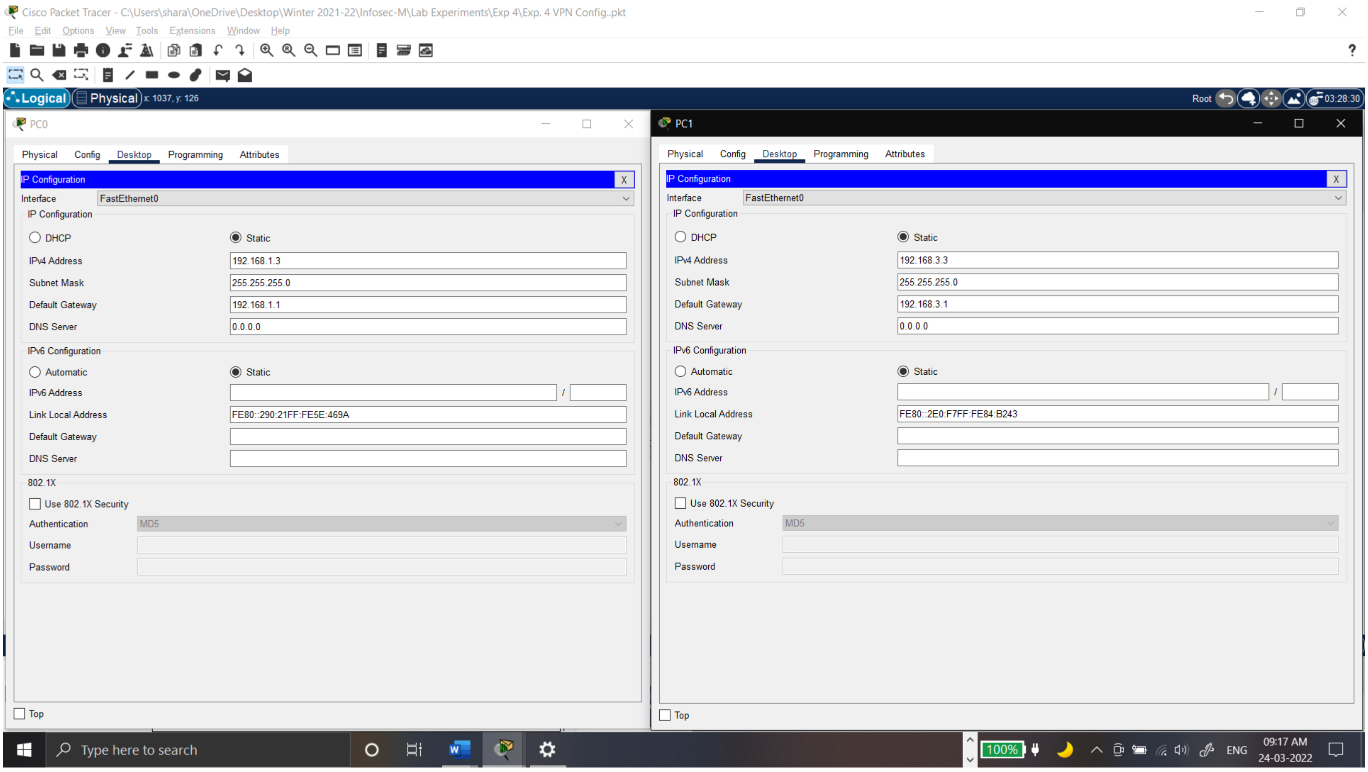


Fig. PC0 and PC1 IP Configurations

PART 2: Configure a Site-to-Site VPN with CISCO IOS

Task 2: Configure IPsec VPN Settings on R1 and R3.

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

In this task, I 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.

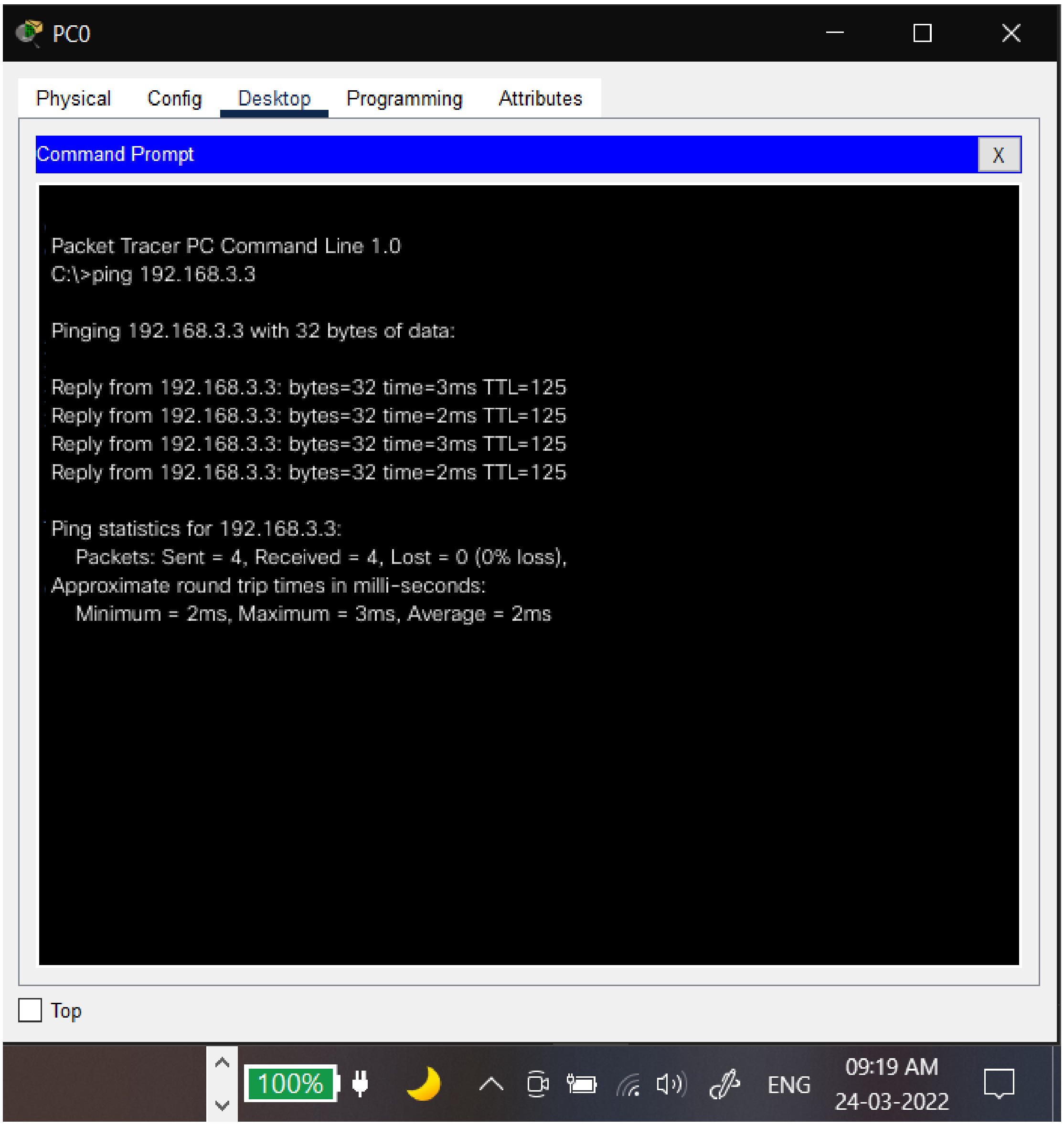


Fig. Verify connectivity from the R1 LAN to the R3 LAN.

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:

- o Implement Internet Key Exchange (IKE) parameters
- o 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
```

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
```

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```
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
```

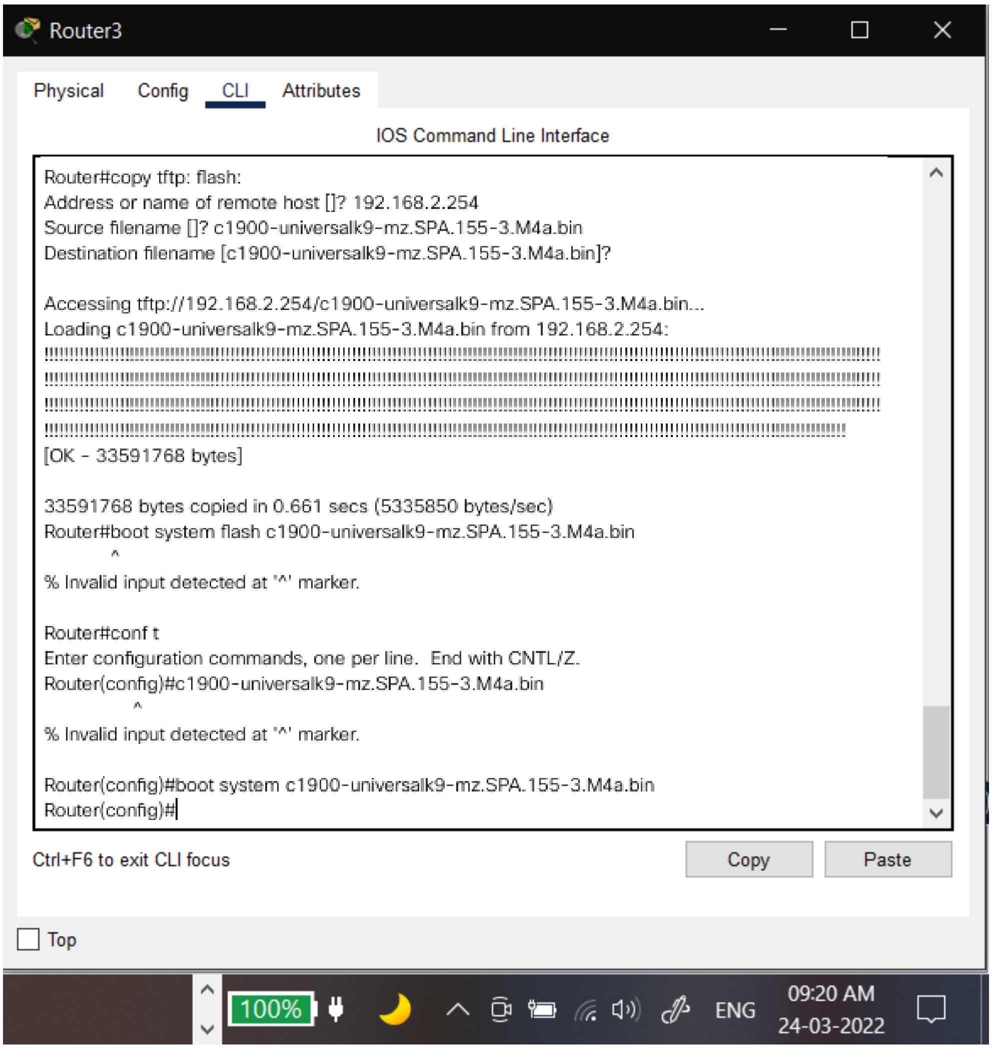


Fig. Update IOS Image using TFTP server

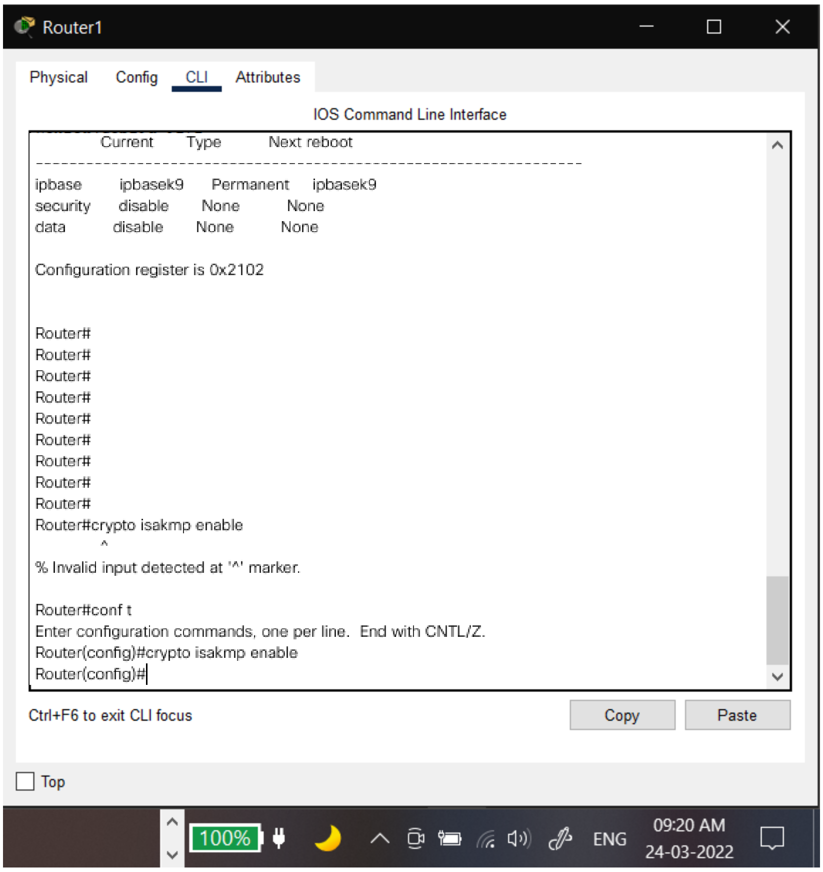
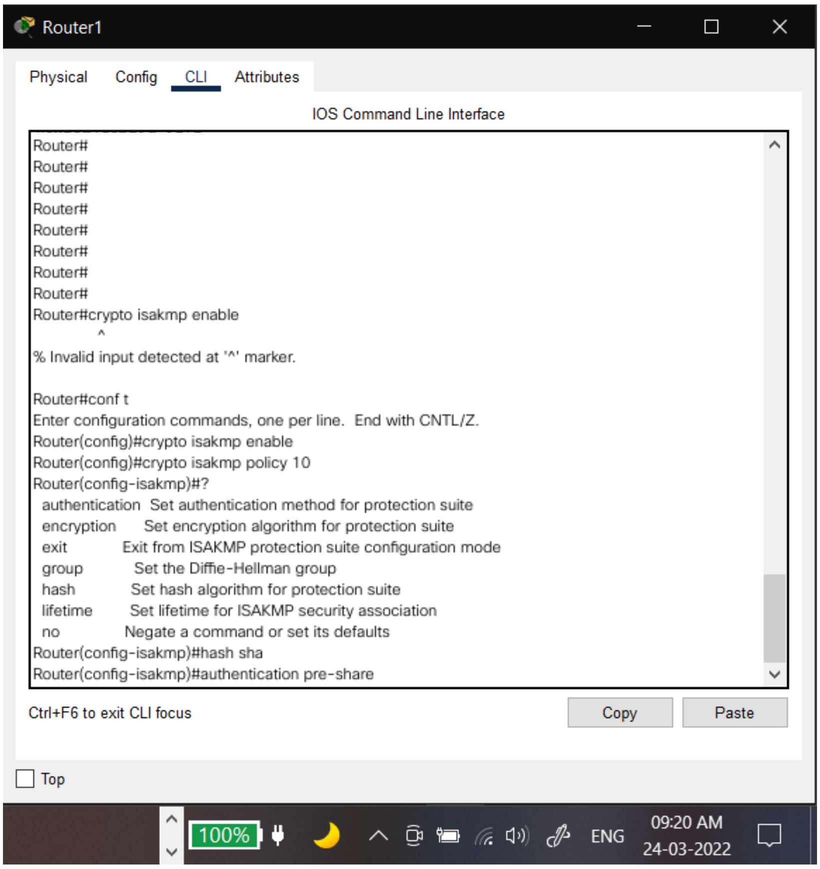


Fig. Check if crypto ISAKMP Router1



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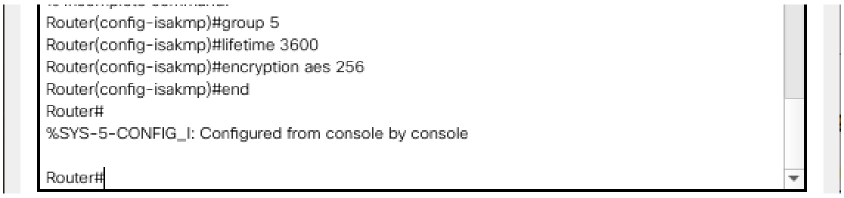

Fig. Configure the IKE Phase 1 ISAKMP policy on R1

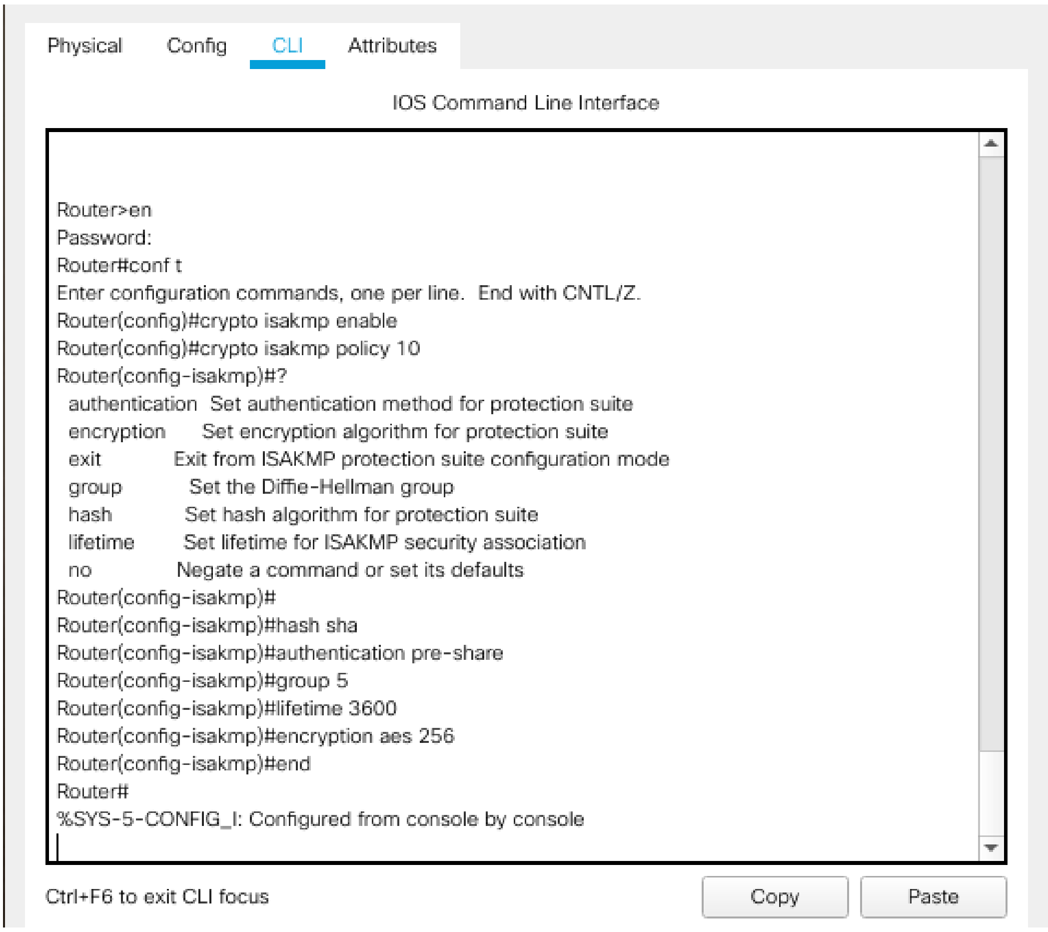

Fig. Configure the IKE Phase 1 ISAKMP policy on Router3.

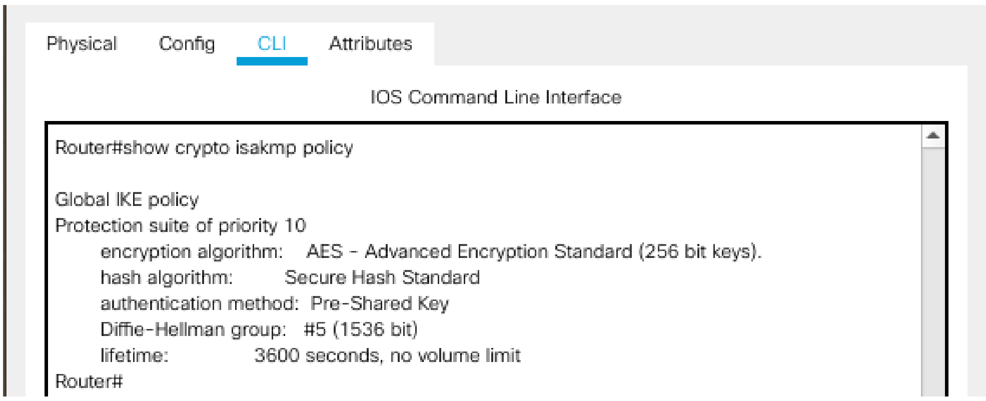

Fig. Crypto isakmp policy in Router3

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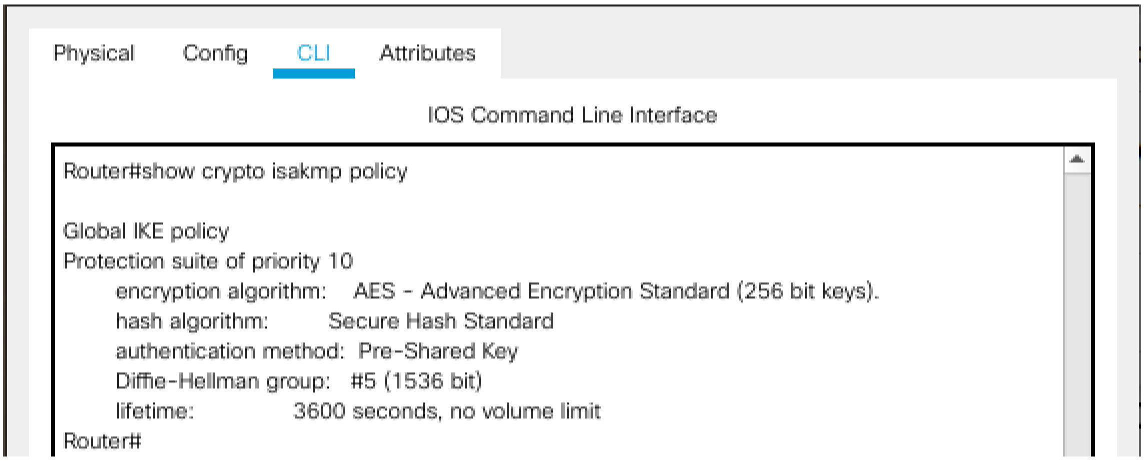


Fig. crypto isakmp policy in Router1

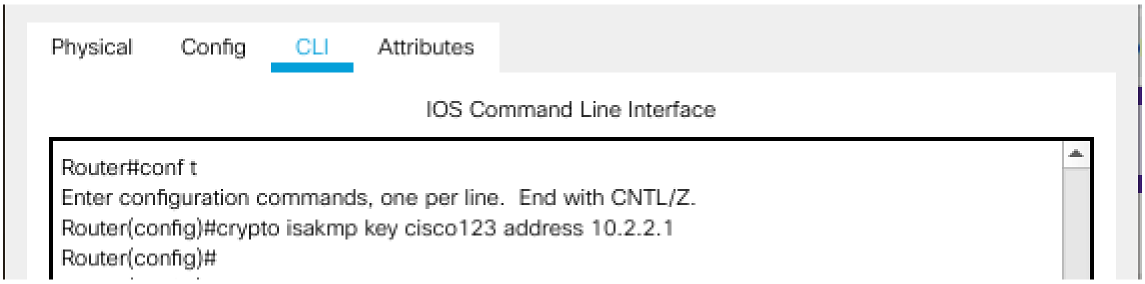


Fig. Configuring pre-shared keys on Router1

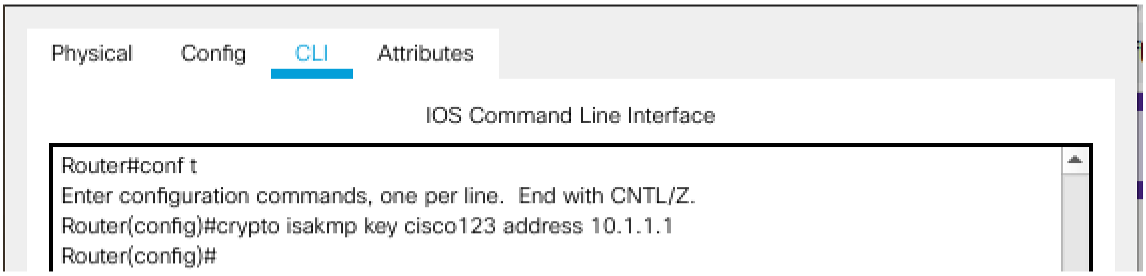


Fig. Configuring pre-shared keys on Router3

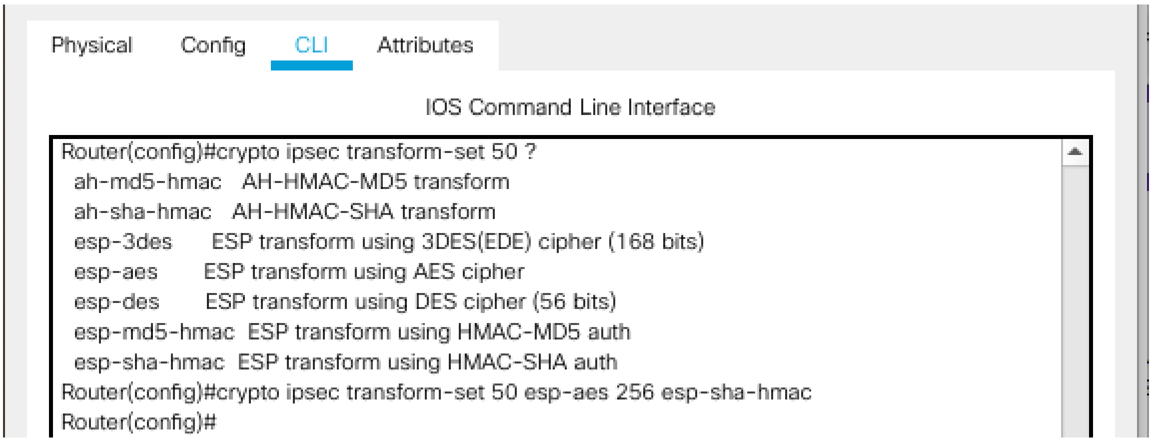


Fig. Configuring the IPsec transform set and lifetime in Router1

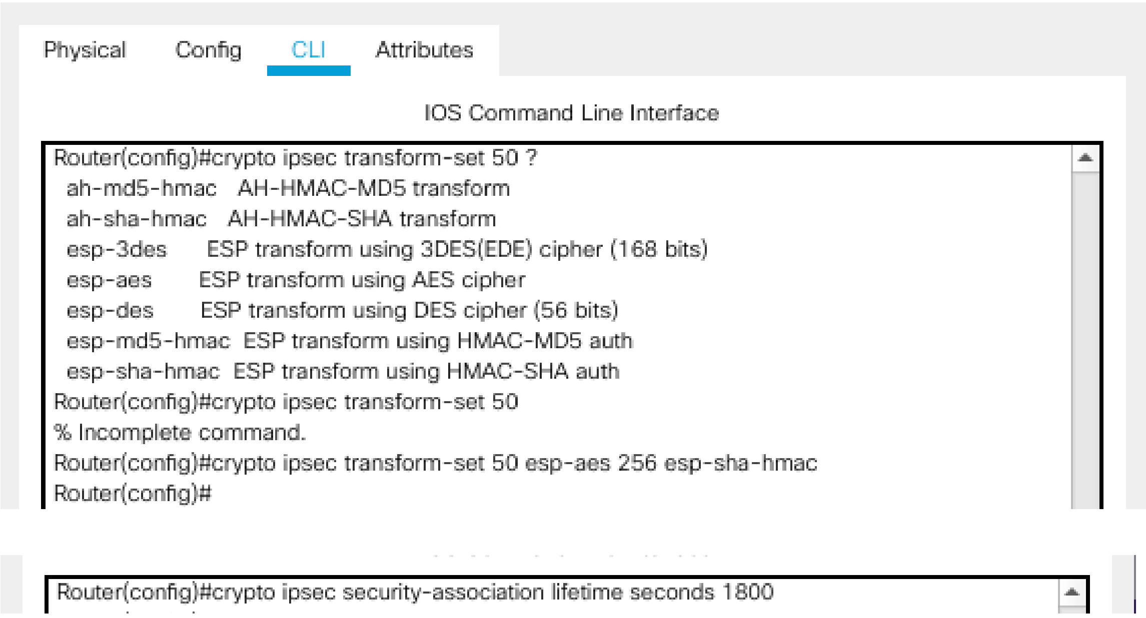


Fig. Configuring the IPsec transform set and lifetime in Router3

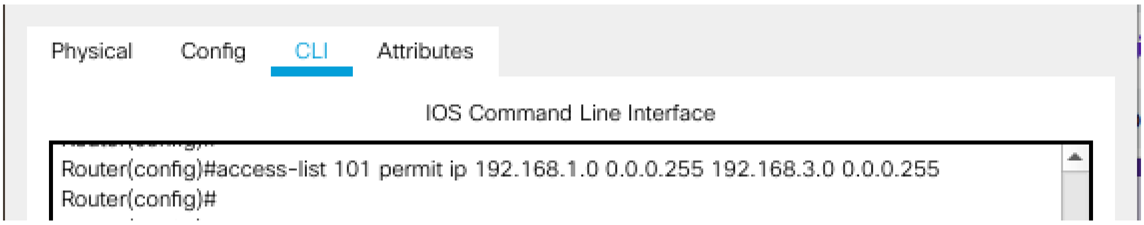


Fig. Configure the IPsec VPN interesting traffic ACL on Router1

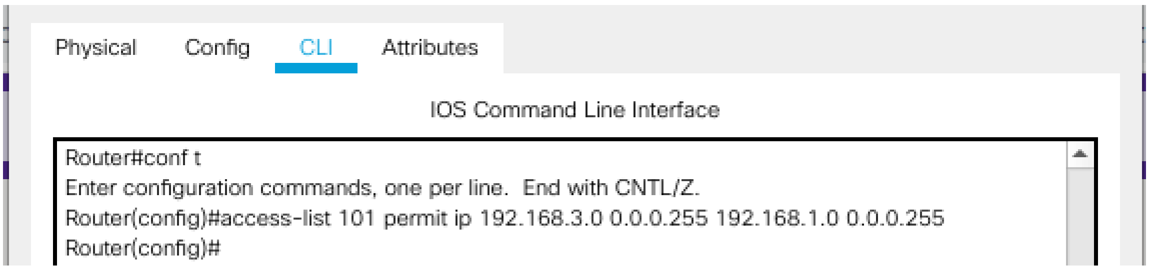


Fig. Configure the IPsec VPN interesting traffic ACL on Router3

Step 4: Configure pre-shared keys.

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
```

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
```

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
```

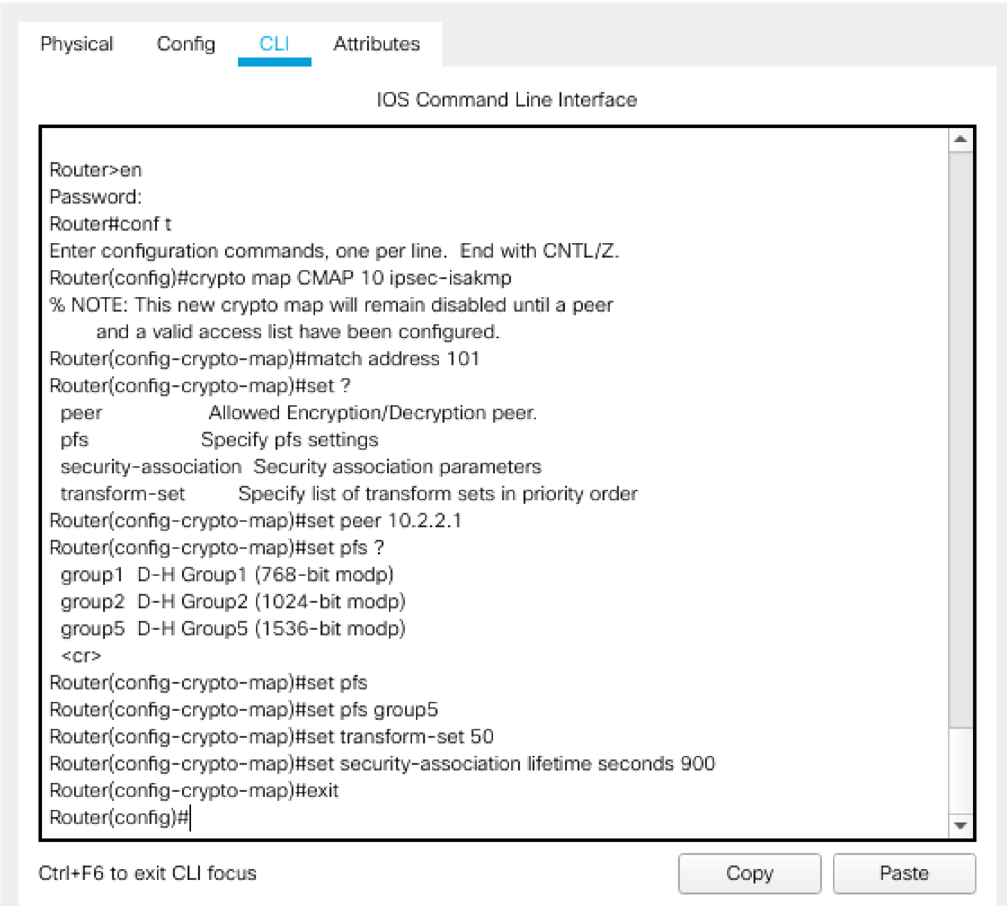
g. Apply the crypto map to interfaces.

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
```



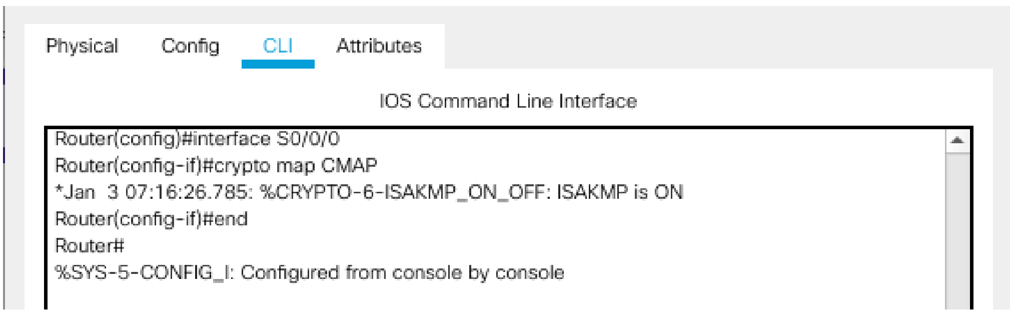
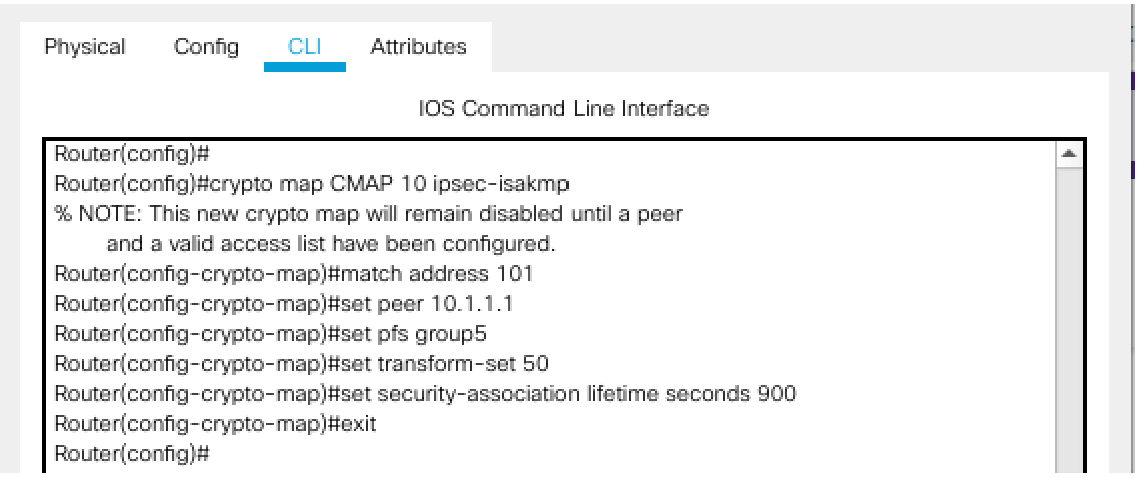


Fig. Creating and applying a crypto map to Router1



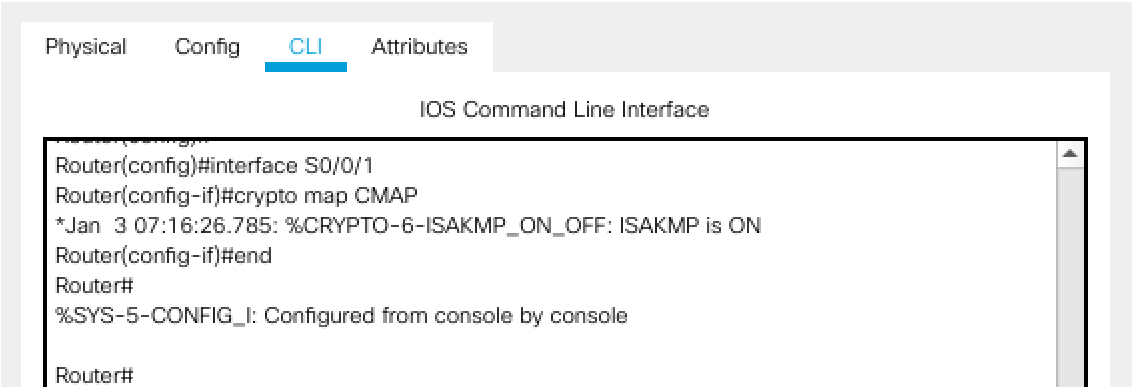


Fig. Creating and applying a crypto map to Router3

Task 3: Verify the Site-to-Site IPsec VPN Configuration.

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

a. Previously, I 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  } ,
```

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```
          }
          Interfaces using crypto map CMAP:
                  Serial0/0/1
```

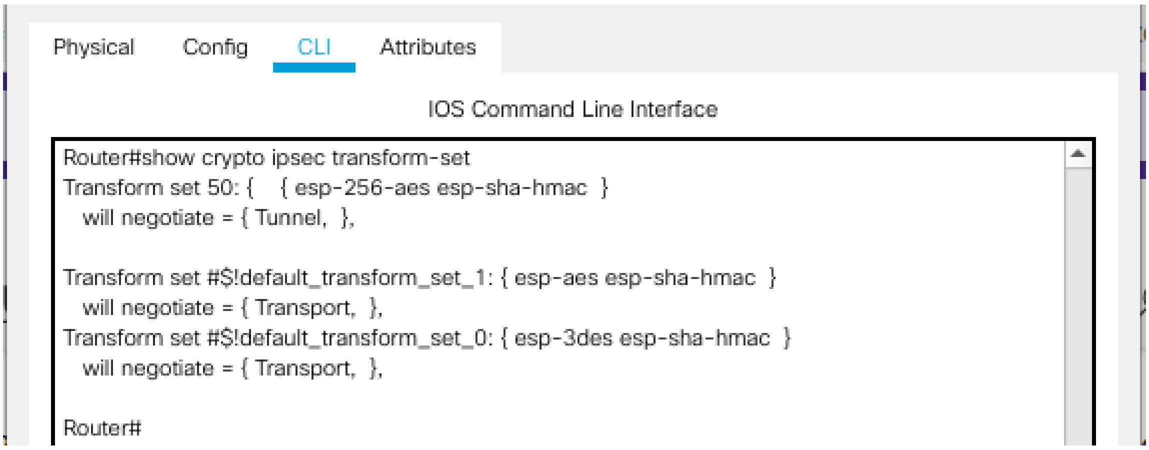

Fig. **show crypto ipsec transform-set in Router1**

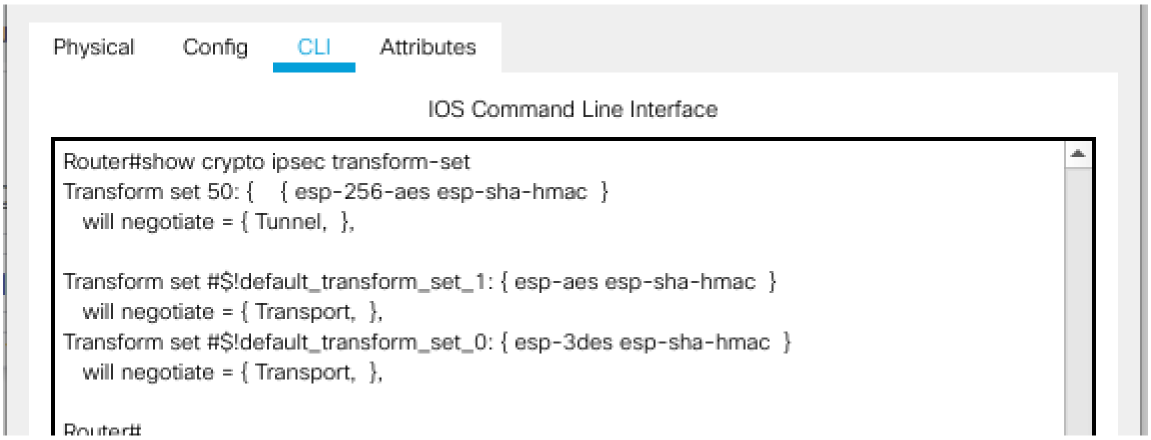

Fig. **show crypto ipsec transform-set in Router3**

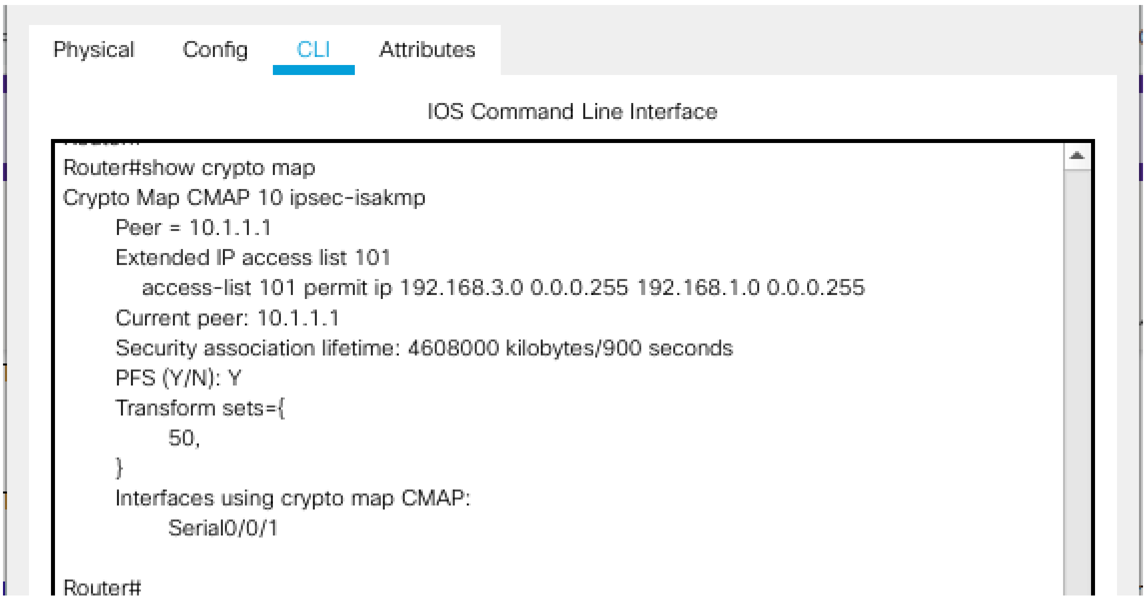

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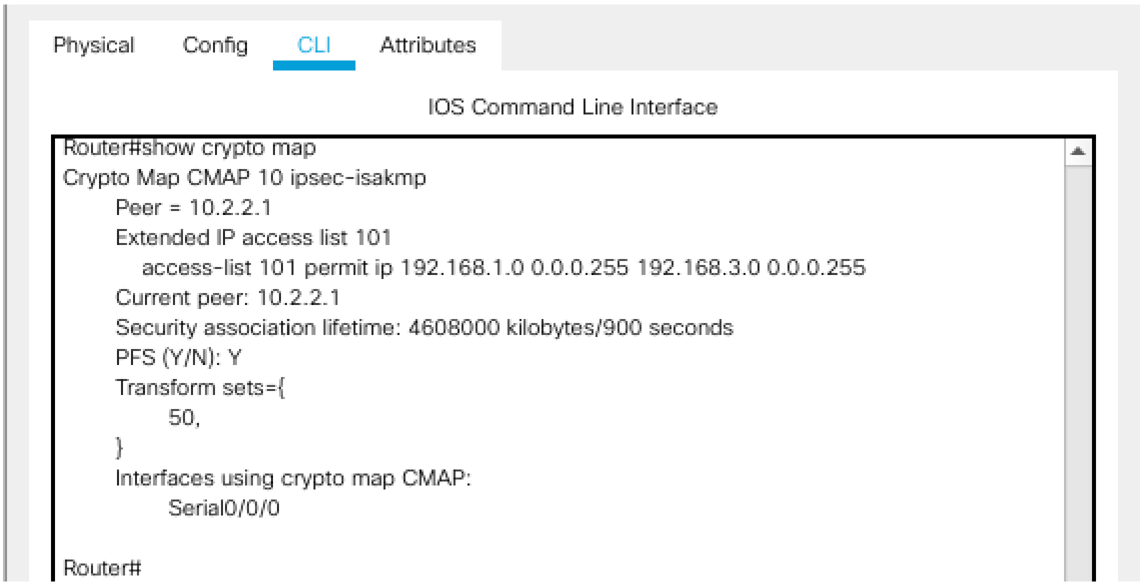
Fig. **show crypto map command in Router3**




```
Router#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
        PFS (Y/N): Y
        Transform sets={
                50,
        }
        Interfaces using crypto map CMAP:
                Serial0/0/0

Router#
```

Fig. **show crypto map command in Router1**

Task 4: 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:
```

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 **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
```

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

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

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
```

c. Ping from PC-A to PC-C. If the pings were successful, issue the **show crypto ipsec sa** command.

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:
```

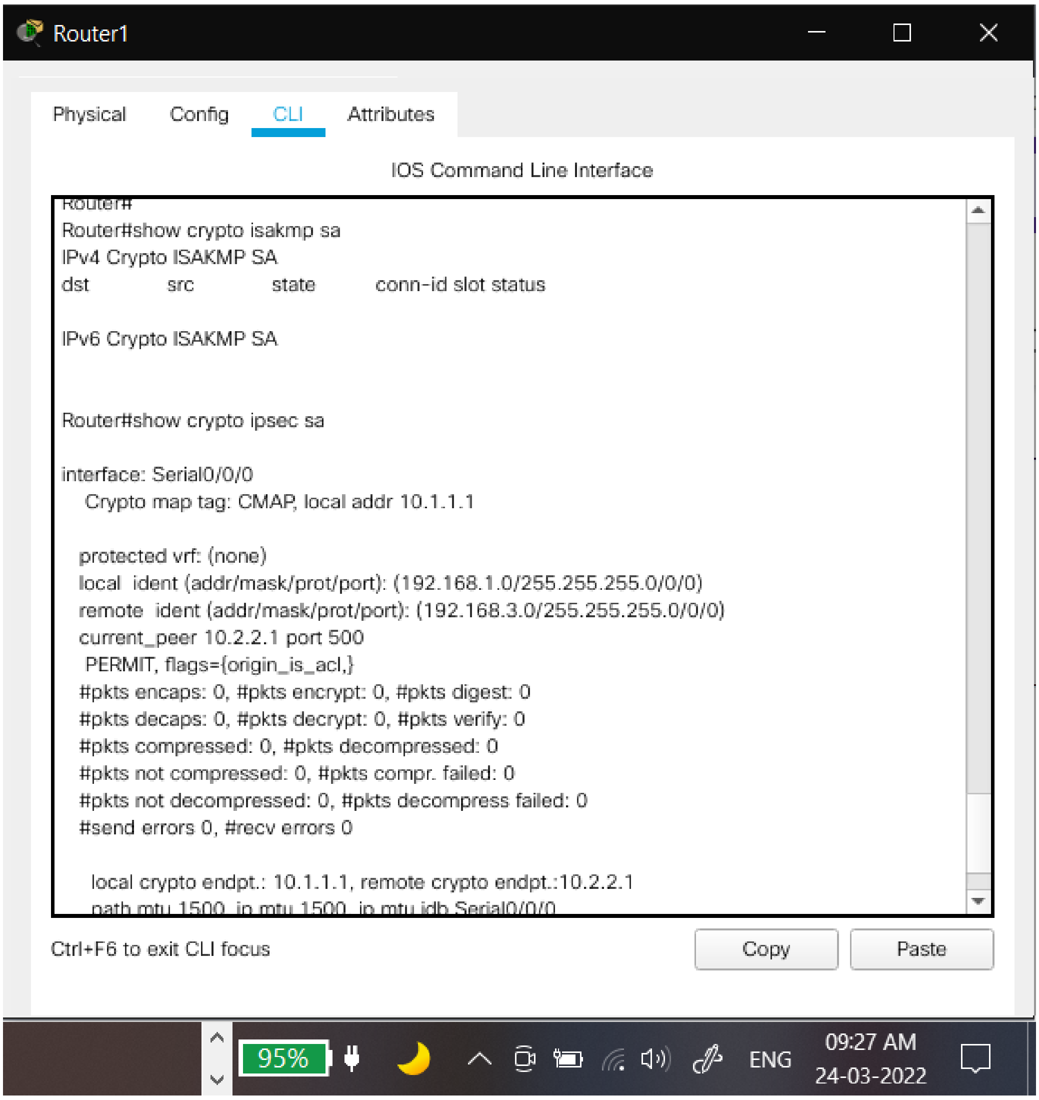


Fig. Display ISAKMP and IPsec security associations for Router1

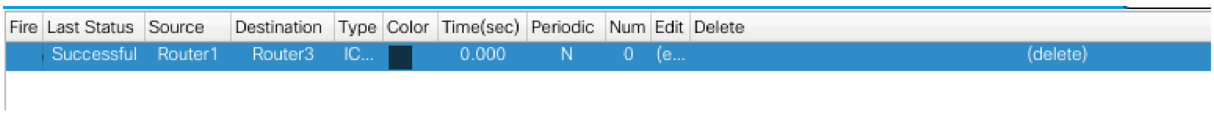


Fig. Ping from R1 to the R3 S0/0/1 interface IP address 10.2.2.1. These pings are successful.

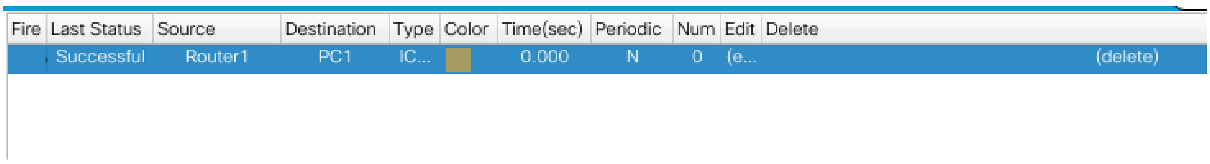


Fig. Ping from R1 to the R3 G0/1 interface IP address 192.168.3.1. These pings are successful.

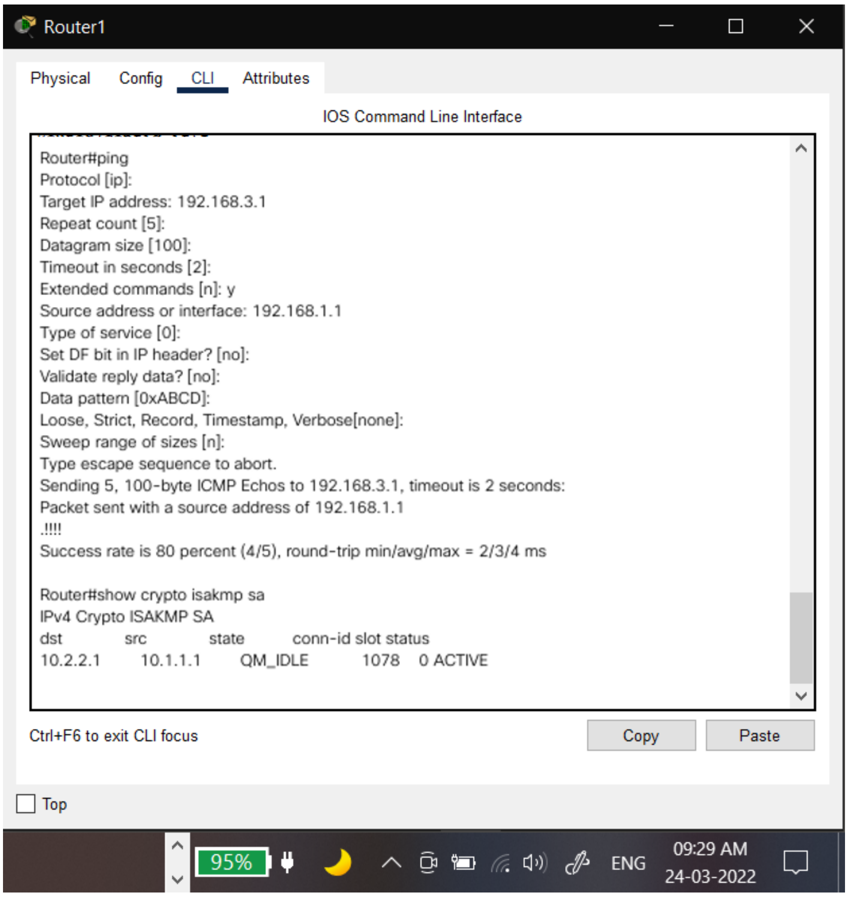


Fig. Generate some interesting test traffic and observe the results.

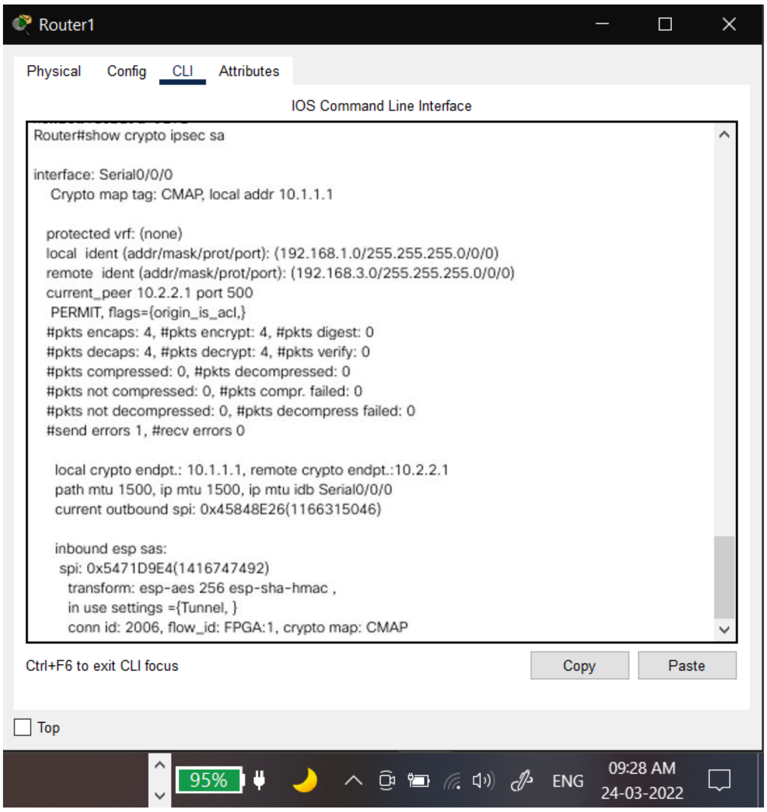


Fig. show crypto ipsec sa from Router1