Configuring and Troubleshooting Cisco Network−Layer Encryption: IPSec and ISAKMP − Part 2

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Contents

Introduction

Part I of this technical report covered Network−Layer Encryption background information and basic Network−Layer Encryption configuration. This part of the document covers IP Security (IPSec) and Internet Security Association and Key Management Protocol (ISAKMP).

IPSec was introduced in Cisco IOS® Software Release 11.3T. It provides a mechanism for secure data transmission and consists of ISAKMP/Oakley and IPSec.

Prerequisites

Requirements

There are no specific requirements for this document.

Components Used

The information in this document is based on the software and hardware versions:

- Cisco IOS Software Release 11.3(T) and later

The information in this document was created from the devices in a specific lab environment. All of the devices used in this document started with a cleared (default) configuration. If your network is live, make sure that you understand the potential impact of any command.

Conventions

For more information on document conventions, see the Cisco Technical Tips Conventions.

Network Layer Encryption Background Information and Configuration

Definitions

This section defines the related terms used throughout this document.

- **Authentication:** The property of knowing that the data received is actually sent by the claimed sender.
- **Confidentiality:** The property of communicating so that the intended recipients know what is being sent but unintended parties cannot determine what is sent.
- **Data Encryption Standard (DES):** The DES utilizes a symmetric key method, also known as a secret key method. This means that if a block of data is encrypted with the key, the encrypted block must be decrypted with the same key, so both the encryptor and the decrypter must use the same key. Even though the encryption method is known and well published, the best publicly known attack method is through brute force. Keys must be tested against the encrypted blocks to see if they can correctly resolve them. As processors become more powerful, the natural life of DES is nearing its end. For instance, a coordinated effort using spare processing power from thousands of computers across the Internet is able to find the 56−bit key to a DES encoded message in 21 days.

  DES is validated every five years by the US National Security Agency (NSA) for meeting the purposes of the US Government. The current approval expires in 1998 and the NSA has indicated that they will not re−certify DES. Moving beyond DES, there are other encryption algorithms which also do not have any known weaknesses other than brute force attacks. For additional information, see DES FIPS 46−2 by the National Institute of Standards and Technology (NIST) .
- **Decryption:** The reverse application of an encryption algorithm to encrypted data, thereby restoring that data to its original, unencrypted state.
- **DSS and Digital Signature Algorithm (DSA):** The DSA was published by the NIST in the Digital Signature Standard (DSS), which is a part of the U.S. government's Capstone project. DSS was selected by NIST, in cooperation with the NSA, to be the digital authentication standard of the U.S. government. The standard was issued on May 19, 1994.
- **Encryption:** The application of a specific algorithm to data so as to alter the appearance of the data making it incomprehensible to those who are not authorized to see the information.
- **Integrity:** The property of ensuring that data is transmitted from source to destination without undetected alteration.
- **Non−repudiation:** The property of a receiver being able to prove that the sender of some data did in fact send the data even though the sender might later desire to deny ever having sent that data.
- **Public Key Cryptography:** Traditional cryptography is based on the sender and receiver of a message knowing and using the same secret key. The sender uses the secret key to encrypt the message, and the receiver uses the same secret key to decrypt the message. This method is known as "secret−key" or "symmetric cryptography." The main issue is getting the sender and receiver to agree on the secret key without anyone else finding out. If they are in separate physical locations, they must trust a courier, or a phone system, or some other transmission medium to prevent the disclosure of the secret key being communicated. Anyone who overhears or intercepts the key in transit can later read, modify, and forge all messages encrypted or authenticated using that key. The generation, transmission, and storage of keys is called key management; all cryptosystems must deal with key management issues. Because all keys in a secret−key cryptosystem must remain secret, secret−key cryptography often has difficulty providing secure key management, especially in open systems with

a large number of users.

The concept of public−key cryptography was introduced in 1976 by Whitfield Diffie and Martin Hellman in order to solve the key management problem. In their concept, each person gets a pair of keys, one called the public key and the other called the private key. Each person's public key is published while the private key is kept secret. The need for the sender and receiver to share secret information is eliminated and all communications involve only public keys, and no private key is ever transmitted or shared. No longer is it necessary to trust some communications channel to be secure against eavesdropping or betrayal. The only requirement is that public keys are associated with their users in a trusted (authenticated) manner (for instance, in a trusted directory). Anyone can send a confidential message simply by using public information, but the message can only be decrypted with a private key, which is in the sole possession of the intended recipient. Furthermore, public−key cryptography can be used not only for privacy (encryption), but for authentication (digital signatures) as well.

- **Public Key Digital Signatures:** To sign a message, a person performs a computation involving both their private key and the message itself. The output is called the digital signature and is attached to the message, which is then sent. A second person verifies the signature by performing a computation involving the message, the purported signature, and the first person's public key. If the result properly holds in a simple mathematical relation, the signature is verified as being genuine. Otherwise, the signature may be fraudulent or the message might have been altered.
- **Public Key Encryption:** When one person wishes to send a secret message to another person, the first person looks up the second person's public key in a directory, uses it to encrypt the message and sends it off. The second person then uses their private key to decrypt the message and read it. No one listening in can decrypt the message. Anyone can send an encrypted message to the second person but only the second person can read it. Clearly, one requirement is that no one can figure out the private key from the corresponding public key.
- **Traffic Analysis:** The analysis of network traffic flow for the purpose of deducing information that is useful to an adversary. Examples of such information are frequency of transmission, the identities of the conversing parties, sizes of packets, Flow Identifiers used, and so on.

IPSec and ISAKMP

This part of the document covers IPSec and ISAKMP.

IPSec was introduced in Cisco IOS Software Release 11.3T. It provides a mechanism for secure data transmission and consists of ISAKMP/Oakley and IPSec.

IPSec Protocol

IPSec protocol (RFC 1825) provides IP network−layer encryption and defines a new set of headers to be added to IP datagrams. These new headers are placed after the IP header and before the Layer 4 protocol (typically TCP or UDP). They provide information for securing the payload of the IP packet, as described below:

The Authentication Header (AH) and Encapsulating Security Payload (ESP) can be used independently or together, although for most applications just one of them is sufficient. For both of these protocols, IPSec does not define the specific security algorithms to use, but rather, provides an open framework for implementing industry−standard algorithms. Initially, most implementations of IPSec support MD5 from RSA Data Security or the Secure Hash Algorithm (SHA) as defined by the US government for integrity and authentication. The DES is currently the most commonly offered bulk encryption algorithm, although RFCs are available that define how to use many other encryption systems, including IDEA, Blowfish, and RC4.

- **AH** (see RFC 1826)

The AH is a mechanism for providing strong integrity and authentication for IP datagrams. It can also provide non−repudiation, depending on which cryptographic algorithm is used and how keying is performed. For example, use of an asymmetric digital signature algorithm, such as RSA, could provide non− repudiation. Confidentiality and protection from traffic analysis are not provided by the AH. Users who need confidentiality should consider using the IP ESP, either in lieu of or in conjunction with the AH. The AH may appear after any other headers that are examined at each hop, and before any other headers that are not examined at an intermediate hop. The IPv4 or IPv6 header immediately preceding the AH will contain the value 51 in its Next Header (or Protocol) field.

- **ESP** (see RFC 1827)

The ESP can appear anywhere after the IP header and before the final transport−layer protocol. The Internet Assigned Numbers Authority has assigned Protocol Number 50 to ESP. The header immediately preceding an ESP header always contains the value 50 in its Next Header (IPv6) or Protocol (IPv4) field. ESP consists of an unencrypted header followed by encrypted data. The encrypted data includes both the protected ESP header fields and the protected user data, which is either an entire IP datagram or an upper−layer protocol frame (such as TCP or UDP).

IP ESP seeks to provide confidentiality and integrity by encrypting data to be protected and placing the encrypted data in the data portion of the IP ESP. Depending on the user's security requirements, this mechanism can be used to encrypt either a transport−layer segment (such as TCP, UDP, ICMP, IGMP) or an entire IP datagram. Encapsulating the protected data is necessary to provide confidentiality for the entire original datagram. Use of this specification will increase the IP protocol processing costs in participating systems and will also increase the communications latency. The increased latency is primarily due to the encryption and decryption required for each IP datagram containing an ESP.

In Tunnel Mode ESP, the original IP datagram is placed in the encrypted portion of the ESP and that entire ESP frame is placed within a datagram having unencrypted IP headers. The information in the unencrypted IP headers is used to route the secure datagram from origin to destination. An unencrypted IP Routing Header might be included between the IP Header and the ESP.

This mode allows a network device, such as a router, to act as an IPSec proxy. That is, the router performs encryption on behalf of the hosts. The source's router encrypts packets and forwards them along the IPSec tunnel. The destination's router decrypts the original IP datagram and forwards it on to the destination system. The major advantage of tunnel mode is that the end systems do not need to be modified to enjoy the benefits of IP Security. Tunnel mode also protects against traffic analysis; with tunnel mode an attacker can only determine the tunnel endpoints and not the true source and destination of the tunneled packets, even if they are the same as the tunnel endpoints. As defined by the IETF, IPSec transport mode can only be used when both the source and the destination systems understand IPSec. In most cases, you deploy IPSec with tunnel mode. Doing so allows you to implement IPSec in the network architecture without modifying the operating system or any applications on your PCs, servers, and hosts.

In Transport Mode ESP, the ESP header is inserted into the IP datagram immediately prior to the transport−layer protocol header (such as TCP, UDP, or ICMP). In this mode, bandwidth is conserved because there are no encrypted IP headers or IP options.

Only the IP payload is encrypted, and the original IP headers are left intact. This mode has the advantage of adding only a few bytes to each packet. It also allows devices on the public network to see the final source and destination of the packet. This capability allows you to enable special processing (for example, quality of service) in the intermediate network based on the information on the IP header. However, the Layer 4 header will be encrypted, limiting the examination of the packet. Unfortunately, by passing the IP header in the clear, transport mode allows an attacker to perform some traffic analysis. For example, an attacker could see when one CEO sent a lot of packets to another CEO. However, the attacker would only know that IP packets were sent; the attacker would not be able to determine if they were e−mail or another application.

ISAKMP/Oakley

While IPSec is the actual protocol that protects the IP datagrams, ISAKMP is the protocol that negotiates policy and provides a common framework for generating keys that IPSec peers share. It does not specify any details of key management or key exchange and is not bound to any key generation technique. Inside of ISAKMP, Cisco uses Oakley for the key exchange protocol. Oakley allows you to choose between five "well−known" groups. Cisco IOS supports group 1 (a 768 bit key) and group 2 (a 1024 bit key). Support for group 5 (a 1536 bit key) was introduced in Cisco IOS Software Release 12.1(3)T.

ISAKMP/Oakley creates an authenticated, secure tunnel between two entities, then negotiates the security association for IPSec. This process requires that the two entities authenticate themselves to each other and establish shared keys.

Both parties must be authenticated to each other. ISAKMP/Oakley supports multiple authentication methods. The two entities must agree on a common authentication protocol through a negotiation process using either RSA signatures, RSA encrypted nonces, or pre−shared keys.

Both parties must have a shared session key in order to encrypt the ISAKMP/Oakley tunnel. The Diffie−Hellman protocol is used to agree on a common session key. The exchange is authenticated as described above to guard against "man−in−the−middle" attacks.

These two steps, authentication and key exchanges, create the ISAKMP/Oakley session association (SA), which is a secure tunnel between the two devices. One side of the tunnel offers a set of algorithms; the other side must then accept one of the offers or reject the entire connection. When the two sides have agreed on which algorithms to use, they must derive key material to use for IPSec with AH, ESP, or both.

IPSec uses a different shared key than ISAKMP/Oakley. The IPSec shared key can be derived by using Diffie−Hellman again to ensure perfect forward secrecy, or by refreshing the shared secret derived from the original Diffie−Hellman exchange that generated the ISAKMP/Oakley SA by hashing it with pseudo−random numbers (nonces). The first method provides greater security but is slower. In most implementations, a combination of the two methods is used. That is, Diffie−Hellman is used for the first key exchange, and then local policy dictates when to use Diffie−Hellman or merely a key refresh. After this is complete, the IPSec SA is established.

Both RSA signatures and RSA encrypted nonces require the public key of the remote peer and they also require the remote peer to have your local public key. Public keys are exchanged in ISAKMP in the form of certificates. These certificates are obtained by enrolling in the Certificate Authority (CA). Currently, if there is no certificate in the router, ISAKMP does not negotiate the protection suite RSA signatures.

Cisco routers do not create certificates. Routers create keys, and request certificates for those keys. The certificates, which bind the routers' keys to their identities, are created and signed by certificate authorities. This is an administrative function, and the certificate authority always requires some sort of verification that the users are who they say they are. This means you cannot just create new certificates on the fly.

The communicating machines exchange preexisting certificates that they have obtained from certificate authorities. The certificates themselves are public information, but the corresponding private keys must be available to anybody who wants to use a certificate to prove identity. But they also must be kept secret from anybody who should not be able to use that identity.

A certificate may identify a user or a machine. It depends on the implementation. Most early systems probably use a certificate to identify a machine. If a certificate identifies a user, the private key corresponding to that certificate has to be stored in such a way that another user on the same machine cannot use it. That generally means that either the key is kept encrypted, or that the key is kept in a smart card. The encrypted−key case is likely to be more common in early implementations. In either case, the user generally has to enter a pass phrase whenever a key is activated.

Note: ISAKMP/Oakley uses UDP port 500 for negotiation. The AH contains 51 in the Protocol Field and ESP contains 50 in the Protocol Field. Make sure you are not filtering these.

For more information on the terminology used in this technical report, refer to the Definitions section.

Cisco IOS Network−Layer Encryption Configuration for IPSec and ISAKMP

The working sample Cisco IOS configurations in this document came directly from lab routers. The only alteration made to them was the removal of unrelated interface configurations. All of the material here came from freely available resources on the Internet or in the Related Information section at the end of this document.

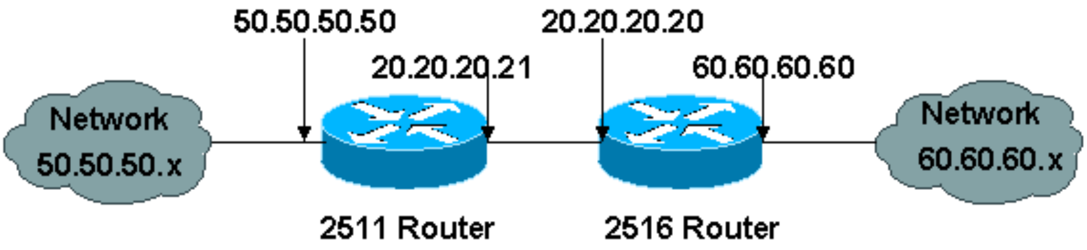
Sample 1: ISAKMP Pre−Shared Keys

Authentication via pre−shared keys is a non−public key alternative. Using this method, each peer shares a secret key that has been exchanged out−of−band and configured into the router. The ability for each side to demonstrate knowledge of this secret (without explicitly mentioning it) authenticates the exchange. This method is adequate for small installations but does have scaling problems. A pre−shared key of "sharedkey" is used below. If hosts share address−based preshared keys, they must use their address identity, which is the default in Cisco IOS Software, so it does not show in the configuration:

```
crypto isakmp identity address
```

Note: There are situations where ISAKMP cannot establish policy and keys for IPSec. If there is no certificate defined in the router and there are only public key−based authentication methods in ISAKMP policy, or if there is no certificate and no pre−shared keys for the peer (either shared directly by address or by a hostname that has been configured with that address), then ISAKMP cannot negotiate with the peer and IPSec does not work.

The following graphic represents the network diagram for this configuration.



Here are configurations for two routers (a Cisco 2511 and a Cisco 2516) back−to−back doing IPSec and ISAKMP authentication based on a preshared key. Comment lines are indicated by an exclamation point as the first character and are ignored if entered into the router. In the configuration below, comments precede certain configuration lines in order to describe them.

Cisco 2511 Configuration

```
cl-2513-2A#write terminal
Building configuration...

Current configuration:
!
version 11.3
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname cl-2513-2A
!

!--- Override the default policy and use
!--- preshared keys for authentication.

crypto isakmp policy 1
 authentication pre-share
 group 2
!

!--- Define our secret shared key so
!--- you do not have to use RSA keys.

crypto isakmp key sharedkey address 20.20.20.20
!

!--- These are the authentication and encryption
!--- settings  defined for "auth2",
!--- which is later applied to the crypto map.

crypto ipsec transform-set auth2 esp-des esp-sha-hmac
!

!--- The crypto map where you define your peer,
!--- transform auth2, and your access list.

crypto map test 10 ipsec-isakmp
 set peer 20.20.20.20
 set transform-set auth2
 match address 133
!
interface Ethernet0
 ip address 50.50.50.50 255.255.255.0
!
interface Serial0
 ip address 20.20.20.21 255.255.255.0
 no ip route-cache
 no ip mroute-cache

!--- Nothing happens unless you apply
!--- the crypto map to an interface.

 crypto map test
!
ip route 0.0.0.0 0.0.0.0 20.20.20.20
!

!--- This is the access list  referenced
!--- in the crypto map; never use "any".
!--- You are encrypting traffic between
!--- the remote Ethernet LANs.

access-list 133 permit ip 50.50.50.0 0.0.0.255 60.60.60.0 0.0.0.255
!
line con 0
line aux 0
line vty 0 4
 login
!
end
```

Cisco 2516 Configuration

```
cl-2513-2B#show run
Building configuration...

Current configuration:
!
version 11.3
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname cl-2513-2B
!
ip subnet-zero
!

!--- Override the default policy and use
!--- preshared keys for authentication.

crypto isakmp policy 1
 authentication pre-share
 group 2

!--- Define the secret shared key so you
!--- do not have to use RSA keys.

crypto isakmp key sharedkey address 20.20.20.21

!--- These are the authentication and encryption
!--- settings  defined for "auth2,"
!--- which is later applied to the crypto map.

crypto ipsec transform-set auth2 esp-des esp-sha-hmac

!--- The crypto map where you define the peer,
!--- transform auth2, and the access list.

crypto map test 10 ipsec-isakmp
 set peer 20.20.20.21
 set transform-set auth2
 match address 144
!
interface Ethernet0
 ip address 60.60.60.60 255.255.255.0
 no ip directed-broadcast
!

!--- Nothing happens unless you apply
!--- the crypto map to an interface.

interface Serial0
 ip address 20.20.20.20 255.255.255.0
 no ip directed-broadcast
 no ip route-cache
 no ip mroute-cache
 clockrate 800000
 crypto map test
!
```

```
ip classless
ip route 0.0.0.0 0.0.0.0 20.20.20.21
!

!--- This is the access list  referenced
!--- in the  crypto map; never use "any".
!--- You are encrypting traffic between
!--- the remote Ethernet LANs.

access-list 144 permit ip 60.60.60.0 0.0.0.255 50.50.50.0 0.0.0.255
!
line con 0
 transport input none
line aux 0
line vty 0 4
 login
!
end
```

The following is **debug** command output.

```
--------------- Preshare with RSA key defined
(need to remove RSA keys) -----

*Mar  1 00:14:48.579: ISAKMP (10): incorrect policy settings.
 Unable to initiate.
*Mar  1 00:14:48.587: ISAKMP (11): incorrect policy settings.
 Unable to initiate......

--------------- Preshare, wrong hostname ---------------

ISAKMP: no pre-shared key based on hostname wan-2511.cisco.com!
%CRYPTO-6-IKMP_MODE_FAILURE: Processing of Aggressive mode
 failed with peer at
20.20.20.21
--------------- Preshare, incompatable policy --------------
wan2511#
*Mar  1 00:33:34.839: ISAKMP (17): processing SA payload. message ID = 0
*Mar  1 00:33:34.843: ISAKMP (17): Checking ISAKMP transform 1
 against priority 1 policy
*Mar  1 00:33:34.843: ISAKMP:      encryption DES-CBC
*Mar  1 00:33:34.843: ISAKMP:      hash SHA
*Mar  1 00:33:34.847: ISAKMP:      default group 2
*Mar  1 00:33:34.847: ISAKMP:      auth pre-share
*Mar  1 00:33:34.847: ISAKMP:      life type in seconds
*Mar  1 00:33:34.851: ISAKMP:      life duration (basic) of 240
*Mar  1 00:33:34.851: ISAKMP (17): atts are acceptable.
 Next payload is 0
*Mar  1 00:33:43.735: ISAKMP (17): processing KE payload.
 message ID = 0
*Mar  1 00:33:54.307: ISAKMP (17): processing NONCE payload.
 message ID = 0
*Mar  1 00:33:54.311: ISAKMP (17): processing ID payload.
 message ID = 0
*Mar  1 00:33:54.331: ISAKMP (17): SKEYID state generated
*Mar  1 00:34:04.867: ISAKMP (17): processing HASH payload.
 message ID = 0
*Mar  1 00:34:04.879: ISAKMP (17): SA has been authenticated
*Mar  1 00:34:06.151: ISAKMP (17): processing SA payload.
 message ID = -1357683133
*Mar  1 00:34:06.155: ISAKMP (17): Checking IPSec proposal 1
*Mar  1 00:34:06.155: ISAKMP: transform 1, AH_MD5_HMAC
*Mar  1 00:34:06.159: ISAKMP:   attributes in transform:
*Mar  1 00:34:06.159: ISAKMP:      encaps is 1
*Mar  1 00:34:06.159: ISAKMP:      SA life type in seconds
```

```
*Mar  1 00:34:06.163: ISAKMP:      SA life duration (basic) of 3600
*Mar  1 00:34:06.163: ISAKMP:      SA life type in kilobytes
*Mar  1 00:34:06.163: ISAKMP:      SA life duration (VPI) of
  0x0 0x46 0x50 0x0
*Mar  1 00:34:06.167: ISAKMP (17): atts not acceptable.
 Next payload is 0
*Mar  1 00:34:06.171: ISAKMP (17): Checking IPSec proposal 1
*Mar  1 00:34:06.171: ISAKMP: transform 1, ESP_DES
*Mar  1 00:34:06.171: ISAKMP:   attributes in transform:
*Mar  1 00:34:06.175: ISAKMP:      encaps is 1
*Mar  1 00:34:06.175: ISAKMP:      SA life type in seconds
*Mar  1 00:34:06.175: ISAKMP:      SA life duration (basic) of 3600
*Mar  1 00:34:06.179: ISAKMP:      SA life type in kilobytes
*Mar  1 00:34:06.179: ISAKMP:      SA life duration (VPI) of
  0x0 0x46 0x50 0x0
*Mar  1 00:34:06.183: ISAKMP:      HMAC algorithm is SHA
*Mar  1 00:34:06.183: ISAKMP (17): atts are acceptable.
*Mar  1 00:34:06.187: ISAKMP (17): SA not acceptable!
%CRYPTO−6−IKMP_MODE_FAILURE: Processing of Quick mode failed
with peer at 20.20.20.20
wan2511#

−−−−−−−−−−−−−−−−− preshare, debug isakmp −−−−−−−−−−−−−−−−−−−

wan2511#
*Mar  1 00:06:54.179: ISAKMP (1): processing SA payload.
 message ID = 0
*Mar  1 00:06:54.179: ISAKMP (1): Checking ISAKMP transform 1
 against priority 1 policy
*Mar  1 00:06:54.183: ISAKMP:      encryption DES−CBC
*Mar  1 00:06:54.183: ISAKMP:      hash SHA
*Mar  1 00:06:54.183: ISAKMP:      default group 2
*Mar  1 00:06:54.187: ISAKMP:      auth pre−share
*Mar  1 00:06:54.187: ISAKMP:      life type in seconds
*Mar  1 00:06:54.187: ISAKMP:      life duration (basic) of 240
*Mar  1 00:06:54.191: ISAKMP (1): atts are acceptable.
 Next payload is 0
*Mar  1 00:07:02.955: ISAKMP (1): processing KE payload.
 message ID = 0
*Mar  1 00:07:13.411: ISAKMP (1): processing NONCE payload.
 message ID = 0
*Mar  1 00:07:13.415: ISAKMP (1): processing ID payload.
 message ID = 0
*Mar  1 00:07:13.435: ISAKMP (1): SKEYID state generated
*Mar  1 00:07:23.903: ISAKMP (1): processing HASH payload.
 message ID = 0
*Mar  1 00:07:23.915: ISAKMP (1): SA has been authenticated
*Mar  1 00:07:25.187: ISAKMP (1): processing SA payload.
 message ID = 1435594195
*Mar  1 00:07:25.187: ISAKMP (1): Checking IPSec proposal 1
*Mar  1 00:07:25.191: ISAKMP: transform 1, AH_SHA_HMAC
*Mar  1 00:07:25.191: ISAKMP:   attributes in transform:
*Mar  1 00:07:25.191: ISAKMP:      encaps is 1
*Mar  1 00:07:25.195: ISAKMP:      SA life type in seconds
*Mar  1 00:07:25.195: ISAKMP:      SA life duration (basic) of 3600
*Mar  1 00:07:25.195: ISAKMP:      SA life type in kilobytes
*Mar  1 00:07:25.199: ISAKMP:      SA life duration (VPI) of
  0x0 0x46 0x50 0x0
*Mar  1 00:07:25.203: ISAKMP (1): atts are acceptable.
*Mar  1 00:07:25.203: ISAKMP (1): Checking IPSec proposal 1
*Mar  1 00:07:25.207: ISAKMP: transform 1, ESP_DES
*Mar  1 00:07:25.207: ISAKMP:   attributes in transform:
*Mar  1 00:07:25.207: ISAKMP:      encaps is 1
*Mar  1 00:07:25.211: ISAKMP:      SA life type in seconds
*Mar  1 00:07:25.211: ISAKMP:      SA life duration (basic) of 3600
*Mar  1 00:07:25.211: ISAKMP:      SA life type in kilobytes
```

```
*Mar  1 00:07:25.215: ISAKMP:      SA life duration (VPI) of
  0x0 0x46 0x50 0x0
*Mar  1 00:07:25.215: ISAKMP:      HMAC algorithm is SHA
*Mar  1 00:07:25.219: ISAKMP (1): atts are acceptable.
*Mar  1 00:07:25.223: ISAKMP (1): processing NONCE payload.
 message ID = 1435594195
*Mar  1 00:07:25.227: ISAKMP (1): processing ID payload.
 message ID = 1435594195
*Mar  1 00:07:25.227: ISAKMP (1): processing ID payload.
 message ID = 1435594195
*Mar  1 00:07:25.639: ISAKMP (1): Creating IPSec SAs
*Mar  1 00:07:25.643:         inbound SA from 20.20.20.20
     to 20.20.20.21
        (proxy 60.60.60.0      to 50.50.50.0     )
*Mar  1 00:07:25.647:         has spi 85067251 and
 conn_id 3 and flags 4
*Mar  1 00:07:25.647:         lifetime of 3600 seconds
*Mar  1 00:07:25.647:         lifetime of 4608000 kilobytes
*Mar  1 00:07:25.651:         outbound SA from 20.20.20.21
     to 20.20.20.20
        (proxy 50.50.50.0      to 60.60.60.0     )
*Mar  1 00:07:25.655:         has spi 57872298 and
 conn_id 4 and flags 4
*Mar  1 00:07:25.655:         lifetime of 3600 seconds
*Mar  1 00:07:25.655:         lifetime of 4608000 kilobytes
*Mar  1 00:07:25.659: ISAKMP (1): Creating IPSec SAs
*Mar  1 00:07:25.659:         inbound SA from 20.20.20.20
   to 20.20.20.21
        (proxy 60.60.60.0      to 50.50.50.0     )
*Mar  1 00:07:25.663:         has spi 538316566 and
 conn_id 5 and flags 4
*Mar  1 00:07:25.663:         lifetime of 3600 seconds
*Mar  1 00:07:25.667:         lifetime of 4608000 kilobytes
*Mar  1 00:07:25.667:         outbound SA from 20.20.20.21
 to 20.20.20.20
        (proxy 50.50.50.0      to 60.60.60.0     )
*Mar  1 00:07:25.671:         has spi 356000275 and
 conn_id 6 and flags 4
*Mar  1 00:07:25.671:         lifetime of 3600 seconds
*Mar  1 00:07:25.675:         lifetime of 4608000 kilobytes
wan2511#

----------------- preshare debug ipsec -------------------
wan2511#
*Mar  1 00:05:26.947: IPSEC(validate_proposal_request):
proposal part #1,
  (key eng. msg.) dest= 20.20.20.21, SRC= 20.20.20.20,
    dest_proxy= 50.50.50.0/0.0.0.0/0/0,
    src_proxy= 60.60.60.0/0.0.0.16/0/0,
    protocol= AH, transform= ah-sha-hmac ,
    lifedur= 0s and 0kb,
    spi= 0x0(0), conn_id= 0, keysize= 0, flags= 0x4
*Mar  1 00:05:26.955: IPSEC(validate_proposal_request):
proposal part #2,
  (key eng. msg.) dest= 20.20.20.21, SRC= 20.20.20.20,
    dest_proxy= 50.50.50.0/0.0.0.0/0/0,
    src_proxy= 60.60.60.0/0.0.0.16/0/0,
    protocol= ESP, transform= esp-des esp-sha-hmac ,
    lifedur= 0s and 0kb,
    spi= 0x0(0), conn_id= 0, keysize= 0, flags= 0x4
*Mar  1 00:05:26.967: IPSEC(key_engine): got a queue event...
*Mar  1 00:05:26.971: IPSEC(spi_response): getting
 spi 203563166 for SA
        from 20.20.20.20     to 20.20.20.21     for prot 2
*Mar  1 00:05:26.975: IPSEC(spi_response): getting
 spi 194838793 for SA
```

```
        from 20.20.20.20     to 20.20.20.21     for prot 3
*Mar  1 00:05:27.379: IPSEC(key_engine): got a queue event...
*Mar  1 00:05:27.379: IPSEC(initialize_sas): ,
  (key eng. msg.) dest= 20.20.20.21, SRC= 20.20.20.20,
    dest_proxy= 50.50.50.0/255.255.255.0/0/0,
    src_proxy= 60.60.60.0/255.255.255.0/0/0,
    protocol= AH, transform= ah-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0xC22209E(203563166), conn_id= 3, keysize= 0, flags= 0x4
*Mar  1 00:05:27.387: IPSEC(initialize_sas): ,
  (key eng. msg.) SRC= 20.20.20.21, dest= 20.20.20.20,
    src_proxy= 50.50.50.0/255.255.255.0/0/0,
    dest_proxy= 60.60.60.0/255.255.255.0/0/0,
    protocol= AH, transform= ah-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0x15E010D(22937869), conn_id= 4, keysize= 0, flags= 0x4
*Mar  1 00:05:27.395: IPSEC(initialize_sas): ,
  (key eng. msg.) dest= 20.20.20.21, SRC= 20.20.20.20,
    dest_proxy= 50.50.50.0/255.255.255.0/0/0,
    src_proxy= 60.60.60.0/255.255.255.0/0/0,
    protocol= ESP, transform= esp-des esp-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0xB9D0109(194838793), conn_id= 5, keysize= 0, flags= 0x4
*Mar  1 00:05:27.403: IPSEC(initialize_sas): ,
  (key eng. msg.) SRC= 20.20.20.21, dest= 20.20.20.20,
    src_proxy= 50.50.50.0/255.255.255.0/0/0,
    dest_proxy= 60.60.60.0/255.255.255.0/0/0,
    protocol= ESP, transform= esp-des esp-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0xDED0AB4(233638580), conn_id= 6, keysize= 0, flags= 0x4
*Mar  1 00:05:27.415: IPSEC(create_sa): sa created,
  (sa) sa_dest= 20.20.20.21, sa_prot= 51,
    sa_spi= 0xC22209E(203563166),
    sa_trans= ah-sha-hmac , sa_conn_id= 3
*Mar  1 00:05:27.419: IPSEC(create_sa): sa created,
  (sa) sa_dest= 20.20.20.20, sa_prot= 51,
    sa_spi= 0x15E010D(22937869),
    sa_trans= ah-sha-hmac , sa_conn_id= 4
*Mar  1 00:05:27.423: IPSEC(create_sa): sa created,
  (sa) sa_dest= 20.20.20.21, sa_prot= 50,
    sa_spi= 0xB9D0109(194838793),
    sa_trans= esp-des esp-sha-hmac , sa_conn_id= 5
*Mar  1 00:05:27.427: IPSEC(create_sa): sa created,
  (sa) sa_dest= 20.20.20.20, sa_prot= 50,
    sa_spi= 0xDED0AB4(233638580),
    sa_trans= esp-des esp-sha-hmac , sa_conn_id= 6
wan2511#

--------------- Preshare, good connection ------
wan2511#
*Mar  1 00:09:45.095: ISAKMP (1): processing SA payload.
 message ID = 0
*Mar  1 00:09:45.099: ISAKMP (1): Checking ISAKMP transform
 1 against priority 1 policy
*Mar  1 00:09:45.099: ISAKMP:      encryption DES-CBC
*Mar  1 00:09:45.103: ISAKMP:      hash SHA
*Mar  1 00:09:45.103: ISAKMP:      default group 2
*Mar  1 00:09:45.103: ISAKMP:      auth pre-share
*Mar  1 00:09:45.107: ISAKMP:      life type in seconds
*Mar  1 00:09:45.107: ISAKMP:      life duration (basic) of 240
*Mar  1 00:09:45.107: ISAKMP (1): atts are acceptable.
Next payload is 0
*Mar  1 00:09:53.867: ISAKMP (1): processing KE payload.
 message ID = 0
*Mar  1 00:10:04.323: ISAKMP (1): processing NONCE payload.
 message ID = 0
```

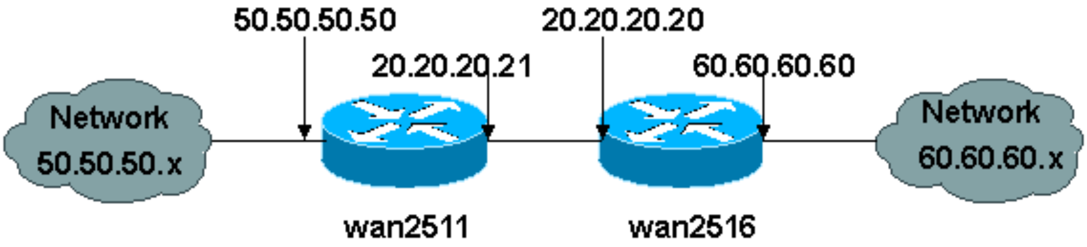
```
*Mar  1 00:10:04.327: ISAKMP (1): processing ID payload.
 message ID = 0
*Mar  1 00:10:04.347: ISAKMP (1): SKEYID state generated
*Mar  1 00:10:15.103: ISAKMP (1): processing HASH payload.
 message ID = 0
*Mar  1 00:10:15.115: ISAKMP (1): SA has been authenticated
*Mar  1 00:10:16.391: ISAKMP (1): processing SA payload.
 message ID = 800032287
*Mar  1 00:10:16.391: ISAKMP (1): Checking IPSec proposal 1
*Mar  1 00:10:16.395: ISAKMP: transform 1, AH_SHA_HMAC
*Mar  1 00:10:16.395: ISAKMP:   attributes in transform:
*Mar  1 00:10:16.395: ISAKMP:      encaps is 1
*Mar  1 00:10:16.399: ISAKMP:      SA life type in seconds
*Mar  1 00:10:16.399: ISAKMP:      SA life duration (basic) of 3600
*Mar  1 00:10:16.399: ISAKMP:      SA life type in kilobytes
*Mar  1 00:10:16.403: ISAKMP:      SA life duration (VPI) of
  0x0 0x46 0x50 0x0
*Mar  1 00:10:16.407: ISAKMP (1): atts are acceptable.
*Mar  1 00:10:16.407: ISAKMP (1): Checking IPSec proposal 1
*Mar  1 00:10:16.411: ISAKMP: transform 1, ESP_DES
*Mar  1 00:10:16.411: ISAKMP:   attributes in transform:
*Mar  1 00:10:16.411: ISAKMP:      encaps is 1
*Mar  1 00:10:16.415: ISAKMP:      SA life type in seconds
*Mar  1 00:10:16.415: ISAKMP:      SA life duration (basic) of 3600
*Mar  1 00:10:16.415: ISAKMP:      SA life type in kilobytes
*Mar  1 00:10:16.419: ISAKMP:      SA life duration (VPI) of
  0x0 0x46 0x50 0x0
*Mar  1 00:10:16.419: ISAKMP:      HMAC algorithm is SHA
*Mar  1 00:10:16.423: ISAKMP (1): atts are acceptable.
*Mar  1 00:10:16.427: IPSEC(validate_proposal_request):
 proposal part #1,
  (key eng. msg.) dest= 20.20.20.21, SRC= 20.20.20.20,
    dest_proxy= 50.50.50.0/0.0.0.0/0/0,
    src_proxy= 60.60.60.0/0.0.0.16/0/0,
    protocol= AH, transform= ah-sha-hmac ,
    lifedur= 0s and 0kb,
    spi= 0x0(0), conn_id= 0, keysize= 0, flags= 0x4
*Mar  1 00:10:16.435: IPSEC(validate_proposal_request):
 proposal part #2,
  (key eng. msg.) dest= 20.20.20.21, SRC= 20.20.20.20,
    dest_proxy= 50.50.50.0/0.0.0.0/0/0,
    src_proxy= 60.60.60.0/0.0.0.16/0/0,
    protocol= ESP, transform= esp-des esp-sha-hmac ,
    lifedur= 0s and 0kb,
    spi= 0x0(0), conn_id= 0, keysize= 0, flags= 0x4
*Mar  1 00:10:16.443: ISAKMP (1): processing NONCE payload.
 message ID = 800032287
*Mar  1 00:10:16.443: ISAKMP (1): processing ID payload.
 message ID = 800032287
*Mar  1 00:10:16.447: ISAKMP (1): processing ID payload.
 message ID = 800032287
*Mar  1 00:10:16.451: IPSEC(key_engine): got a queue event...
*Mar  1 00:10:16.455: IPSEC(spi_response): getting
spi 16457800 for SA
        from 20.20.20.20     to 20.20.20.21     for prot 2
*Mar  1 00:10:16.459: IPSEC(spi_response): getting
spi 305534655 for SA
        from 20.20.20.20     to 20.20.20.21     for prot 3
*Mar  1 00:10:17.095: ISAKMP (1): Creating IPSec SAs
*Mar  1 00:10:17.095:         inbound SA from 20.20.20.20
     to 20.20.20.21
        (proxy 60.60.60.0      to 50.50.50.0     )
*Mar  1 00:10:17.099:         has spi 16457800 and conn_id 3
 and flags 4
*Mar  1 00:10:17.103:         lifetime of 3600 seconds
*Mar  1 00:10:17.103:         lifetime of 4608000 kilobytes
```

```
*Mar  1 00:10:17.103:         outbound SA from 20.20.20.21
     to 20.20.20.20
        (proxy 50.50.50.0      to 60.60.60.0     )
*Mar  1 00:10:17.107:         has spi 507120385 and conn_id 4
 and flags 4
*Mar  1 00:10:17.111:         lifetime of 3600 seconds
*Mar  1 00:10:17.111:         lifetime of 4608000 kilobytes
*Mar  1 00:10:17.115: ISAKMP (1): Creating IPSec SAs
*Mar  1 00:10:17.115:         inbound SA from 20.20.20.20
to 20.20.20.21
        (proxy 60.60.60.0      to 50.50.50.0     )
*Mar  1 00:10:17.119:         has spi 305534655 and
conn_id 5 and flags 4
*Mar  1 00:10:17.119:         lifetime of 3600 seconds
*Mar  1 00:10:17.123:         lifetime of 4608000 kilobytes
*Mar  1 00:10:17.123:         outbound SA from 20.20.20.21
     to 20.20.20.20
        (proxy 50.50.50.0      to 60.60.60.0     )
*Mar  1 00:10:17.127:         has spi 554175376 and
conn_id 6 and flags 4
*Mar  1 00:10:17.127:         lifetime of 3600 seconds
*Mar  1 00:10:17.131:         lifetime of 4608000 kilobytes
*Mar  1 00:10:17.139: IPSEC(key_engine): got a queue event...
*Mar  1 00:10:17.143: IPSEC(initialize_sas): ,
  (key eng. msg.) dest= 20.20.20.21, SRC= 20.20.20.20,
    dest_proxy= 50.50.50.0/255.255.255.0/0/0,
    src_proxy= 60.60.60.0/255.255.255.0/0/0,
    protocol= AH, transform= ah-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0xFB2048(16457800), conn_id= 3, keysize= 0,
 flags= 0x4
*Mar  1 00:10:17.151: IPSEC(initialize_sas): ,
  (key eng. msg.) SRC= 20.20.20.21, dest= 20.20.20.20,
    src_proxy= 50.50.50.0/255.255.255.0/0/0,
    dest_proxy= 60.60.60.0/255.255.255.0/0/0,
    protocol= AH, transform= ah-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0x1E3A0B01(507120385), conn_id= 4, keysize= 0,
 flags= 0x4
*Mar  1 00:10:17.159: IPSEC(initialize_sas): ,
  (key eng. msg.) dest= 20.20.20.21, SRC= 20.20.20.20,
    dest_proxy= 50.50.50.0/255.255.255.0/0/0,
    src_proxy= 60.60.60.0/255.255.255.0/0/0,
    protocol= ESP, transform= esp-des esp-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0x123616BF(305534655), conn_id= 5, keysize= 0,
 flags= 0x4
*Mar  1 00:10:17.167: IPSEC(initialize_sas): ,
  (key eng. msg.) SRC= 20.20.20.21, dest= 20.20.20.20,
    src_proxy= 50.50.50.0/255.255.255.0/0/0,
    dest_proxy= 60.60.60.0/255.255.255.0/0/0,
    protocol= ESP, transform= esp-des esp-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0x21080B90(554175376), conn_id= 6, keysize= 0,
 flags= 0x4
*Mar  1 00:10:17.175: IPSEC(create_sa): sa created,
  (sa) sa_dest= 20.20.20.21, sa_prot= 51,
    sa_spi= 0xFB2048(16457800),
    sa_trans= ah-sha-hmac , sa_conn_id= 3
*Mar  1 00:10:17.179: IPSEC(create_sa): sa created,
  (sa) sa_dest= 20.20.20.20, sa_prot= 51,
    sa_spi= 0x1E3A0B01(507120385),
    sa_trans= ah-sha-hmac , sa_conn_id= 4
*Mar  1 00:10:17.183: IPSEC(create_sa): sa created,
  (sa) sa_dest= 20.20.20.21, sa_prot= 50,
    sa_spi= 0x123616BF(305534655),
    sa_trans= esp-des esp-sha-hmac , sa_conn_id= 5
*Mar  1 00:10:17.187: IPSEC(create_sa): sa created,
  (sa) sa_dest= 20.20.20.20, sa_prot= 50,
    sa_spi= 0x21080B90(554175376),
    sa_trans= esp-des esp-sha-hmac , sa_conn_id= 6
*Mar  1 00:10:36.583: ISADB: reaper checking SA, conn_id = 1
wan2511#
```

Sample 2: ISAKMP: RSA−Encrypted Authentication

In this scenario, a shared secret key is not created. Each router generates its own RSA key. Then each router needs to configure the peer's RSA public key. This is a manual process and has obvious scaling limitations. In other words, a router needs to have a public RSA key for each peer with which it wishes to have a security association.

The following document represents the network diagram for this sample cofiguration.



In this example, each router generates an RSA key pair (you never see the RSA private key you generate) and configures the remote peers' public RSA key.

```
wan2511(config)#crypto key generate rsa
The name for the keys will be: wan2511.cisco.com
Choose the size of the key modulus in the range of 360 to 2048 for your
  General Purpose Keys. Choosing a key modulus greater than 512 may take
  a few minutes.

How many bits in the modulus [512]:
Generating RSA keys ...
[OK]

wan2511(config)#^Z
wan2511#
wan2511#show crypto key mypubkey rsa
% Key pair was generated at: 00:09:04 UTC Mar 1 1993
Key name: wan2511.cisco.com
Usage:    General Purpose Key
Key Data:
 305C300D 06092A86 4886F70D 01010105 00034B00 30480241 00E9007B E5CD7DC8
 6E1C0423 92044254 92C972AD 0CCE9796 86797EAA B6C4EFF0 0F0A5378 6AFAE43B
 3A2BD92F 98039DAC 08741E82 5D9053C4 D9CFABC1 AB54E0E2 BB020301 0001
wan2511#

wan2511(config)#crypto key pubkey−chain rsa
wan2511(config−pubkey−chain)#named−key wan2516.cisco.com
wan2511(config−pubkey−key)#key−string
Enter a public key as a hexidecimal number ....

wan2511(config−pubkey)#$86F70D 01010105 00034B00 30480241 00DC3DDC 59885F14
wan2511(config−pubkey)#$D918DE FC7ADB76 B0B9DD1A ABAF4884 009E758C 4064C699
wan2511(config−pubkey)#$220CB9 31E267F8 0259C640 F8DE4169 1F020301 0001
wan2511(config−pubkey)#quit
wan2511(config−pubkey−key)#^Z
```

```
wan2511#
wan2511#show crypto key pubkey-chain rsa
Key name: wan2516.cisco.com
Key usage: general purpose
Key source: manually entered
Key data:
 305C300D 06092A86 4886F70D 01010105 00034B00 30480241 00DC3DDC 59885F14
 1AB30DCB 794AB5C7 82D918DE FC7ADB76 B0B9DD1A ABAF4884 009E758C 4064C699
 3BC9D17E C47581DC 50220CB9 31E267F8 0259C640 F8DE4169 1F020301 0001


wan2511#
wan2511#write terminal
Building configuration...

Current configuration:
!
version 11.3
service timestamps debug datetime msec
no service password-encryption
!
hostname wan2511
!
enable password ww
!
no ip domain-lookup
ip host wan2516.cisco.com 20.20.20.20
ip domain-name cisco.com
!
crypto isakmp policy 1
 authentication rsa-encr
 group 2
 lifetime 240
crypto isakmp identity hostname
!
crypto ipsec transform-set auth2 ah-sha-hmac esp-des esp-sha-hmac
!
crypto map test 10 ipsec-isakmp
 set peer 20.20.20.20
 set transform-set auth2
 match address 133
!
crypto key pubkey-chain rsa
 named-key wan2516.cisco.com
  key-string
   305C300D 06092A86 4886F70D 01010105 00034B00 30480241 00DC3DDC 59885F14
   1AB30DCB 794AB5C7 82D918DE FC7ADB76 B0B9DD1A ABAF4884 009E758C 4064C699
   3BC9D17E C47581DC 50220CB9 31E267F8 0259C640 F8DE4169 1F020301 0001
  quit
!
interface Ethernet0
 ip address 50.50.50.50 255.255.255.0
!
interface Serial0
 ip address 20.20.20.21 255.255.255.0
 encapsulation ppp
 no ip mroute-cache
 crypto map test
!
interface Serial1
 no ip address
 shutdown
!
ip classless
ip route 0.0.0.0 0.0.0.0 10.11.19.254
ip route 60.0.0.0 255.0.0.0 20.20.20.20
```

```
access-list 133 permit ip 50.50.50.0 0.0.0.255 60.60.60.0 0.0.0.255
!
line con 0
 exec-timeout 0 0
 password ww
 login
line 1 6
 modem InOut
 transport input all
 speed 115200
 flowcontrol hardware
line 7 16
 autoselect ppp
 modem InOut
 transport input all
 speed 115200
 flowcontrol hardware
line aux 0
 login local
 modem InOut
 transport input all
 flowcontrol hardware
line vty 0 4
 password ww
 login
!
end



wan2511#
-----------------

wan2516(config)#crypto key generate rsa
The name for the keys will be: wan2516.cisco.com
Choose the size of the key modulus in the range of 360 to 2048 for your
  General Purpose Keys. Choosing a key modulus greater than 512 may take
  a few minutes.

How many bits in the modulus [512]:
Generating RSA keys ...
[OK]

wan2516#show crypto key mypubkey rsa
% Key pair was generated at: 00:06:35 UTC Mar 1 1993
Key name: wan2516.cisco.com
Usage:    General Purpose Key
Key Data:
 305C300D 06092A86 4886F70D 01010105 00034B00 30480241 00DC3DDC 59885F14
 1AB30DCB 794AB5C7 82D918DE FC7ADB76 B0B9DD1A ABAF4884 009E758C 4064C699
 3BC9D17E C47581DC 50220CB9 31E267F8 0259C640 F8DE4169 1F020301 0001
wan2516#

-------
wan2516(config)#crypto key exchange ?
  dss  Exchange DSS keys
-------

wan2516(config)#crypto key pubkey-chain rsa
wan2516(config-pubkey-chain)#named-key wan2511.cisco.com
wan2516(config-pubkey-key)#key-string
Enter a public key as a hexidecimal number ....

wan2516(config-pubkey)#$86F70D 01010105 00034B00 30480241 00E9007B E5CD7DC8
wan2516(config-pubkey)#$C972AD 0CCE9796 86797EAA B6C4EFF0 0F0A5378 6AFAE43B
wan2516(config-pubkey)#$741E82 5D9053C4 D9CFABC1 AB54E0E2 BB020301 0001
```

```
wan2516(config-pubkey)#quit
wan2516(config-pubkey-key)#^Z

wan2516#show crypto key pubkey rsa
Key name: wan2511.cisco.com
Key usage: general purpose
Key source: manually entered
Key data:
 305C300D 06092A86 4886F70D 01010105 00034B00 30480241 00E9007B E5CD7DC8
 6E1C0423 92044254 92C972AD 0CCE9796 86797EAA B6C4EFF0 0F0A5378 6AFAE43B
 3A2BD92F 98039DAC 08741E82 5D9053C4 D9CFABC1 AB54E0E2 BB020301 0001



wan2516#
------------------------
wan2516#write terminal
Building configuration...

Current configuration:
!
version 11.3
no service pad
service timestamps debug datetime msec
no service password-encryption
service udp-small-servers
service tcp-small-servers
!
hostname wan2516
!
enable password ww
!
no ip domain-lookup
ip host wan2511.cisco.com 20.20.20.21
ip domain-name cisco.com
!
crypto isakmp policy 1
 authentication rsa-encr
 group 2
 lifetime 240
crypto isakmp identity hostname
!
crypto ipsec transform-set auth2 ah-sha-hmac esp-des esp-sha-hmac
!
crypto map test 10 ipsec-isakmp
 set peer 20.20.20.21
 set transform-set auth2
 match address 144
!
crypto key pubkey-chain rsa
 named-key wan2511.cisco.com
  key-string
   305C300D 06092A86 4886F70D 01010105 00034B00 30480241 00E9007B E5CD7DC8
   6E1C0423 92044254 92C972AD 0CCE9796 86797EAA B6C4EFF0 0F0A5378 6AFAE43B
   3A2BD92F 98039DAC 08741E82 5D9053C4 D9CFABC1 AB54E0E2 BB020301 0001
  quit
!
hub ether 0 1
 link-test
 auto-polarity
!
interface Loopback0
 ip address 70.70.70.1 255.255.255.0
 no ip route-cache
 no ip mroute-cache
!
```

```
interface Ethernet0
 ip address 60.60.60.60 255.255.255.0
!
interface Serial0
 ip address 20.20.20.20 255.255.255.0
 encapsulation ppp
 clockrate 2000000
 crypto map test
!
interface Serial1
 no ip address
 no ip route-cache
 no ip mroute-cache
 shutdown
!
interface BRI0
 no ip address
 no ip route-cache
 no ip mroute-cache
 shutdown
!
ip default-gateway 20.20.20.21
ip classless
ip route 0.0.0.0 0.0.0.0 20.20.20.21
access-list 144 permit ip 60.60.60.0 0.0.0.255 50.50.50.0 0.0.0.255
!
line con 0
 exec-timeout 0 0
 password ww
 login
line aux 0
 password ww
 login
 modem InOut
 transport input all
 flowcontrol hardware
line vty 0 4
 password ww
 login
!
end

wan2516#

--------------- RSA-enc missing RSA Keys ---------

*Mar  1 00:02:51.147: ISAKMP: No cert, and no keys (public or pre-shared)
        with remote peer 20.20.20.21
*Mar  1 00:02:51.151: ISAKMP: No cert, and no keys (public or pre-shared)
        with remote peer 20.20.20.21

--------------- RSA-enc good connection -----------------
wan2511#
*Mar  1 00:21:46.375: ISAKMP (1): processing SA payload.
message ID = 0
*Mar  1 00:21:46.379: ISAKMP (1): Checking ISAKMP
transform 1 against
      priority 1 policy
*Mar  1 00:21:46.379: ISAKMP:      encryption DES-CBC
*Mar  1 00:21:46.379: ISAKMP:      hash SHA
*Mar  1 00:21:46.383: ISAKMP:      default group 2
*Mar  1 00:21:46.383: ISAKMP:      auth RSA encr
*Mar  1 00:21:46.383: ISAKMP:      life type in seconds
*Mar  1 00:21:46.387: ISAKMP:      life duration (basic)
of 240
*Mar  1 00:21:46.387: ISAKMP (1): atts are acceptable.
```

```
Next payload is 0
*Mar  1 00:21:46.391: Crypto engine 0: generate alg param

*Mar  1 00:21:55.159: CRYPTO_ENGINE: Dh phase 1 status: 0
*Mar  1 00:21:55.163: CRYPTO: DH gen phase 1 status for
conn_id 1 slot 0:OK
*Mar  1 00:21:55.167: ISAKMP (1): Unable to get router
cert to find DN!
*Mar  1 00:21:55.171: ISAKMP (1): SA is doing RSA
encryption authentication
*Mar  1 00:22:04.351: ISAKMP (1): processing KE payload.
message ID = 0
*Mar  1 00:22:04.351: Crypto engine 0: generate alg param

*Mar  1 00:22:14.767: CRYPTO: DH gen phase 2 status for
conn_id 1 slot 0:OK
*Mar  1 00:22:14.771: ISAKMP (1): processing ID payload.
message ID = 0
*Mar  1 00:22:14.775: Crypto engine 0: RSA decrypt
with private key
*Mar  1 00:22:15.967: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:16.167: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:16.367: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:16.579: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:16.787: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:16.987: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:17.215: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:17.431: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:17.539: CRYPTO: RSA private decrypt
finished with status=OK
*Mar  1 00:22:17.543: ISAKMP (1): processing NONCE
payload. message ID = 0
*Mar  1 00:22:17.543: Crypto engine 0: RSA decrypt
with private key
*Mar  1 00:22:18.735: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:18.947: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:19.155: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:19.359: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:19.567: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:19.767: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:19.975: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:20.223: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:20.335: CRYPTO: RSA private decrypt
finished with status=OK
*Mar  1 00:22:20.347: Crypto engine 0: create ISAKMP
SKEYID for conn id 1
*Mar  1 00:22:20.363: ISAKMP (1): SKEYID state generated
*Mar  1 00:22:20.367: Crypto engine 0: RSA encrypt
with public key
*Mar  1 00:22:20.567: CRYPTO: RSA public encrypt
```

```
finished with status=OK
*Mar  1 00:22:20.571: Crypto engine 0: RSA encrypt
with public key
*Mar  1 00:22:20.767: CRYPTO: RSA public encrypt
finished with status=OK
*Mar  1 00:22:20.775: ISAKMP (1): processing KE
payload. message ID = 0
*Mar  1 00:22:20.775: ISAKMP (1): processing ID
payload. message ID = 0
*Mar  1 00:22:20.779: Crypto engine 0: RSA decrypt
with private key
*Mar  1 00:22:21.959: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:22.187: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:22.399: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:22.599: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:22.811: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:23.019: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:23.223: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:23.471: CRYPTO_ENGINE: key process
suspended and continued
*Mar  1 00:22:23.583: CRYPTO: RSA private decrypt
finished with status=OK
*Mar  1 00:22:23.583: ISAKMP (1): processing NONCE
payload. message ID = 0
%CRYPTO−6−IKMP_AUTH_FAIL: Authentication method 4
failed with host 20.20.20.20
%CRYPTO−6−IKMP_MODE_FAILURE: Processing of Main
mode failed with peer
  at 20.20.20.20
*Mar  1 00:22:36.955: ISAKMP (1): processing HASH
payload. message ID = 0
*Mar  1 00:22:36.959: generate hmac context for conn id 1
*Mar  1 00:22:36.971: ISAKMP (1): SA has been authenticated
*Mar  1 00:22:36.975: generate hmac context for conn id 1
*Mar  1 00:22:37.311: generate hmac context for conn id 1
*Mar  1 00:22:37.319: ISAKMP (1): processing SA payload.
message ID = −114148384
*Mar  1 00:22:37.319: ISAKMP (1): Checking IPSec proposal 1
*Mar  1 00:22:37.323: ISAKMP: transform 1, AH_SHA_HMAC
*Mar  1 00:22:37.323: ISAKMP: attributes in transform:
*Mar  1 00:22:37.327: ISAKMP: encaps is 1
*Mar  1 00:22:37.327: ISAKMP: SA life type in seconds
*Mar  1 00:22:37.327: ISAKMP: SA life duration (basic) of 3600
*Mar  1 00:22:37.331: ISAKMP: SA life type in kilobytes
*Mar  1 00:22:37.331: ISAKMP: SA life duration (VPI) of
  0x0 0x46 0x50 0x0
*Mar  1 00:22:37.335: ISAKMP (1): atts are acceptable.
*Mar  1 00:22:37.335: ISAKMP (1): Checking IPSec proposal 1
*Mar  1 00:22:37.339: ISAKMP: transform 1, ESP_DES
*Mar  1 00:22:37.339: ISAKMP: attributes in transform:
*Mar  1 00:22:37.339: ISAKMP: encaps is 1
*Mar  1 00:22:37.343: ISAKMP: SA life type in seconds
*Mar  1 00:22:37.343: ISAKMP: SA life duration (basic) of 3600
*Mar  1 00:22:37.347: ISAKMP: SA life type in kilobytes
*Mar  1 00:22:37.347: ISAKMP: SA life duration (VPI) of
  0x0 0x46 0x50 0x0
*Mar  1 00:22:37.351: ISAKMP: HMAC algorithm is SHA
*Mar  1 00:22:37.351: ISAKMP (1): atts are acceptable.
*Mar  1 00:22:37.355: IPSEC(validate_proposal_request):
```

```
proposal part #1,
  (key eng. msg.) dest= 20.20.20.21, SRC= 20.20.20.20,
    dest_proxy= 50.50.50.0/0.0.0.0/0/0,
    src_proxy= 60.60.60.0/0.0.0.16/0/0,
    protocol= AH, transform= ah-sha-hmac ,
    lifedur= 0s and 0kb,
    spi= 0x0(0), conn_id= 0, keysize= 0, flags= 0x4
*Mar  1 00:22:37.363: IPSEC(validate_proposal_request):
proposal part #2,
  (key eng. msg.) dest= 20.20.20.21, SRC= 20.20.20.20,
    dest_proxy= 50.50.50.0/0.0.0.0/0/0,
    src_proxy= 60.60.60.0/0.0.0.16/0/0,
    protocol= ESP, transform= esp-des esp-sha-hmac ,
    lifedur= 0s and 0kb,
    spi= 0x0(0), conn_id= 0, keysize= 0, flags= 0x4
*Mar  1 00:22:37.371: ISAKMP (1): processing NONCE payload.
      message ID = -114148384
*Mar  1 00:22:37.375: ISAKMP (1): processing ID payload.
message ID = -114148384
*Mar  1 00:22:37.375: ISAKMP (1): processing ID payload.
 message ID = -114148384
*Mar  1 00:22:37.379: IPSEC(key_engine): got a queue event...
*Mar  1 00:22:37.383: IPSEC(spi_response): getting spi
531040311 for SA
        from 20.20.20.20     to 20.20.20.21 for prot 2
*Mar  1 00:22:37.387: IPSEC(spi_response): getting spi
220210147 for SA
        from 20.20.20.20     to 20.20.20.21     for prot 3
*Mar  1 00:22:37.639: generate hmac context for conn id 1
*Mar  1 00:22:37.931: generate hmac context for conn id 1
*Mar  1 00:22:37.975: ISAKMP (1): Creating IPSec SAs
*Mar  1 00:22:37.975: inbound SA from 20.20.20.20
   to 20.20.20.21
        (proxy 60.60.60.0      to 50.50.50.0     )
*Mar  1 00:22:37.979:  has spi 531040311 and conn_id 2 and flags 4
*Mar  1 00:22:37.979:   lifetime of 3600 seconds
*Mar  1 00:22:37.983:    lifetime of 4608000 kilobytes
*Mar  1 00:22:37.983:  outbound SA from 20.20.20.21
 to 20.20.20.20
        (proxy 50.50.50.0 to 60.60.60.0     )
*Mar  1 00:22:37.987: has spi 125043658 and
conn_id 3 and flags 4
*Mar  1 00:22:37.987: lifetime of 3600 seconds
*Mar  1 00:22:37.991: lifetime of 4608000 kilobytes
*Mar  1 00:22:37.991: ISAKMP (1): Creating IPSec SAs
*Mar  1 00:22:37.991: inbound SA from 20.20.20.20 to 20.20.20.21
        (proxy 60.60.60.0 to 50.50.50.0     )
*Mar  1 00:22:37.995: has spi 220210147 and conn_id 4 and flags 4
*Mar  1 00:22:37.999: lifetime of 3600 seconds
*Mar  1 00:22:37.999: lifetime of 4608000 kilobytes
*Mar  1 00:22:38.003: outbound SA from 20.20.20.21 to 20.20.20.20
        (proxy 50.50.50.0      to 60.60.60.0     )
*Mar  1 00:22:38.003: has spi 299247102 and
conn_id 5 and flags 4
*Mar  1 00:22:38.007: lifetime of 3600 seconds
*Mar  1 00:22:38.007: lifetime of 4608000 kilobytes
*Mar  1 00:22:38.011: IPSEC(key_engine): got a queue event...
*Mar  1 00:22:38.015: IPSEC(initialize_sas): ,
  (key eng. msg.) dest= 20.20.20.21, SRC= 20.20.20.20,
    dest_proxy= 50.50.50.0/255.255.255.0/0/0,
    src_proxy= 60.60.60.0/255.255.255.0/0/0,
    protocol= AH, transform= ah-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0x1FA70837(531040311), conn_id= 2, keysize= 0, flags= 0x4
*Mar  1 00:22:38.023: IPSEC(initialize_sas): ,
  (key eng. msg.) SRC= 20.20.20.21, dest= 20.20.20.20,
    src_proxy= 50.50.50.0/255.255.255.0/0/0,
    dest_proxy= 60.60.60.0/255.255.255.0/0/0,
    protocol= AH, transform= ah-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0x77403CA(125043658), conn_id= 3, keysize= 0, flags= 0x4
*Mar  1 00:22:38.031: IPSEC(initialize_sas): ,
  (key eng. msg.) dest= 20.20.20.21, SRC= 20.20.20.20,
    dest_proxy= 50.50.50.0/255.255.255.0/0/0,
    src_proxy= 60.60.60.0/255.255.255.0/0/0,
    protocol= ESP, transform= esp-des esp-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0xD2023E3(220210147), conn_id= 4, keysize= 0, flags= 0x4
*Mar  1 00:22:38.039: IPSEC(initialize_sas): ,
  (key eng. msg.) SRC= 20.20.20.21, dest= 20.20.20.20,
    src_proxy= 50.50.50.0/255.255.255.0/0/0,
    dest_proxy= 60.60.60.0/255.255.255.0/0/0,
    protocol= ESP, transform= esp-des esp-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0x11D625FE(299247102), conn_id= 5, keysize= 0, flags= 0x4
*Mar  1 00:22:38.047: IPSEC(create_sa): sa created,
  (sa) sa_dest= 20.20.20.21, sa_prot= 51,
    sa_spi= 0x1FA70837(531040311),
    sa_trans= ah-sha-hmac , sa_conn_id= 2
*Mar  1 00:22:38.051: IPSEC(create_sa): sa created,
  (sa) sa_dest= 20.20.20.20, sa_prot= 51,
    sa_spi= 0x77403CA(125043658),
    sa_trans= ah-sha-hmac , sa_conn_id= 3
*Mar  1 00:22:38.055: IPSEC(create_sa): sa created,
  (sa) sa_dest= 20.20.20.21, sa_prot= 50,
    sa_spi= 0xD2023E3(220210147),
    sa_trans= esp-des esp-sha-hmac , sa_conn_id= 4
*Mar  1 00:22:38.063: IPSEC(create_sa): sa created,
  (sa) sa_dest= 20.20.20.20, sa_prot= 50,
    sa_spi= 0x11D625FE(299247102),
    sa_trans= esp-des esp-sha-hmac , sa_conn_id= 5
wan2511#

----------- RSA-ENC ISAKMP debugs good connection ---
wan2511#
*Mar  1 00:27:23.279: ISAKMP (6): processing SA payload.
 message ID = 0
*Mar  1 00:27:23.279: ISAKMP (6): Checking ISAKMP
 transform 1 against
      priority 1 policy
*Mar  1 00:27:23.283: ISAKMP: encryption DES-CBC
*Mar  1 00:27:23.283: ISAKMP: hash SHA
*Mar  1 00:27:23.283: ISAKMP: default group 2
*Mar  1 00:27:23.287: ISAKMP: auth RSA encr
*Mar  1 00:27:23.287: ISAKMP: life type in seconds
*Mar  1 00:27:23.287: ISAKMP: life duration (basic) of 240
*Mar  1 00:27:23.291: ISAKMP (6): atts are acceptable.
Next payload is 0
*Mar  1 00:27:32.055: ISAKMP (6): Unable to get
router cert to find DN!
*Mar  1 00:27:32.055: ISAKMP (6): SA is doing RSA
encryption authentication
*Mar  1 00:27:41.183: ISAKMP (6): processing KE payload.
message ID = 0
*Mar  1 00:27:51.779: ISAKMP (6): processing ID payload.
 message ID = 0
*Mar  1 00:27:54.507: ISAKMP (6): processing NONCE payload.
 message ID = 0
*Mar  1 00:27:57.239: ISAKMP (6): SKEYID state generated
*Mar  1 00:27:57.627: ISAKMP (6): processing KE payload.
 message ID = 0
*Mar  1 00:27:57.631: ISAKMP (6): processing ID payload.
```

```
 message ID = 0
*Mar  1 00:28:00.371: ISAKMP (6): processing NONCE payload.

 message ID = 0
%CRYPTO−6−IKMP_AUTH_FAIL: Authentication method 4 failed
with host 20.20.20.20
%CRYPTO−6−IKMP_MODE_FAILURE: Processing of Main mode failed
 with peer at 20.20.20.20
*Mar  1 00:28:13.587: ISAKMP (6): processing HASH payload.
 message ID = 0
*Mar  1 00:28:13.599: ISAKMP (6): SA has been authenticated
*Mar  1 00:28:13.939: ISAKMP (6): processing SA payload.
 message ID = −161552401
*Mar  1 00:28:13.943: ISAKMP (6): Checking IPSec proposal 1
*Mar  1 00:28:13.943: ISAKMP: transform 1, AH_SHA_HMAC
*Mar  1 00:28:13.943: ISAKMP:   attributes in transform:
*Mar  1 00:28:13.947: ISAKMP: encaps is 1
*Mar  1 00:28:13.947: ISAKMP: SA life type in seconds
*Mar  1 00:28:13.947: ISAKMP: SA life duration (basic) of 3600
*Mar  1 00:28:13.951: ISAKMP: SA life type in kilobytes
*Mar  1 00:28:13.951: ISAKMP: SA life duration (VPI) of
  0x0 0x46 0x50 0x0
*Mar  1 00:28:13.955: ISAKMP (6): atts are acceptable.
*Mar  1 00:28:13.959: ISAKMP (6): Checking IPSec proposal 1
*Mar  1 00:28:13.959: ISAKMP: transform 1, ESP_DES
*Mar  1 00:28:13.959: ISAKMP: attributes in transform:
*Mar  1 00:28:13.963: ISAKMP: encaps is 1
*Mar  1 00:28:13.963: ISAKMP: SA life type in seconds
*Mar  1 00:28:13.963: ISAKMP: SA life duration (basic) of 3600
*Mar  1 00:28:13.967: ISAKMP: SA life type in kilobytes
*Mar  1 00:28:13.967: ISAKMP: SA life duration (VPI) of
  0x0 0x46 0x50 0x0
*Mar  1 00:28:13.971: ISAKMP:      HMAC algorithm is SHA
*Mar  1 00:28:13.971: ISAKMP (6): atts are acceptable.
*Mar  1 00:28:13.975: ISAKMP (6): processing NONCE payload.
 message ID = −161552401
*Mar  1 00:28:13.979: ISAKMP (6): processing ID payload.
 message ID = −161552401
*Mar  1 00:28:13.979: ISAKMP (6): processing ID payload.
 message ID = −161552401
*Mar  1 00:28:14.391: ISAKMP (6): Creating IPSec SAs
*Mar  1 00:28:14.391: inbound SA from 20.20.20.20 to 20.20.20.21
        (proxy 60.60.60.0 to 50.50.50.0     )
*Mar  1 00:28:14.395: has spi 437593758 and conn_id 7 and flags 4
*Mar  1 00:28:14.399: lifetime of 3600 seconds
*Mar  1 00:28:14.399: lifetime of 4608000 kilobytes
*Mar  1 00:28:14.403: outbound SA from 20.20.20.21 to 20.20.20.20
        (proxy 50.50.50.0 to 60.60.60.0     )
*Mar  1 00:28:14.403: has spi 411835612 and conn_id 8 and flags 4
*Mar  1 00:28:14.407: lifetime of 3600 seconds
*Mar  1 00:28:14.407: lifetime of 4608000 kilobytes
*Mar  1 00:28:14.411: ISAKMP (6): Creating IPSec SAs
*Mar  1 00:28:14.411: inbound SA from 20.20.20.20 to 20.20.20.21
        (proxy 60.60.60.0 to 50.50.50.0     )
*Mar  1 00:28:14.415: has spi 216990519 and conn_id 9 and flags 4
*Mar  1 00:28:14.415: lifetime of 3600 seconds
*Mar  1 00:28:14.419: lifetime of 4608000 kilobytes
*Mar  1 00:28:14.419: outbound SA from 20.20.20.21 to 20.20.20.20
        (proxy 50.50.50.0 to 60.60.60.0     )
*Mar  1 00:28:14.423: has spi 108733569 and conn_id 10 and flags 4
*Mar  1 00:28:14.423: lifetime of 3600 seconds
*Mar  1 00:28:14.427: lifetime of 4608000 kilobytes
wan2511#

−−−−−−−−−−−−−−−−−−−−−−−−−− RSA−enc IPSEC debug −−−−−−−
wan2511#
```

```
*Mar  1 00:30:32.155: ISAKMP (11): Unable to get
router cert to find DN!
wan2511#show debug
Cryptographic Subsystem:
  Crypto IPSEC debugging is on
wan2511#
wan2511#
wan2511#
wan2511#
%CRYPTO-6-IKMP_AUTH_FAIL: Authentication method
4 failed with host 20.20.20.20
%CRYPTO-6-IKMP_MODE_FAILURE: Processing of Main
mode failed with peer at
20.20.20.20
*Mar  1 00:31:13.931: IPSEC(validate_proposal_request):
 proposal part #1,
  (key eng. msg.) dest= 20.20.20.21, SRC= 20.20.20.20,
    dest_proxy= 50.50.50.0/0.0.0.0/0/0,
    src_proxy= 60.60.60.0/0.0.0.16/0/0,
    protocol= AH, transform= ah-sha-hmac ,
    lifedur= 0s and 0kb,
    spi= 0x0(0), conn_id= 0, keysize= 0, flags= 0x4
*Mar  1 00:31:13.935: IPSEC(validate_proposal_request):
 proposal part #2,
  (key eng. msg.) dest= 20.20.20.21, SRC= 20.20.20.20,
    dest_proxy= 50.50.50.0/0.0.0.0/0/0,
    src_proxy= 60.60.60.0/0.0.0.16/0/0,
    protocol= ESP, transform= esp-des esp-sha-hmac ,
    lifedur= 0s and 0kb,
    spi= 0x0(0), conn_id= 0, keysize= 0, flags= 0x4
*Mar  1 00:31:13.947: IPSEC(key_engine): got a queue event...
*Mar  1 00:31:13.951: IPSEC(spi_response): getting
spi 436869446 for SA
        from 20.20.20.20     to 20.20.20.21 for prot 2
*Mar  1 00:31:13.955: IPSEC(spi_response): getting
 spi 285609740 for SA
        from 20.20.20.20     to 20.20.20.21 for prot 3
*Mar  1 00:31:14.367: IPSEC(key_engine): got a queue event...
*Mar  1 00:31:14.367: IPSEC(initialize_sas): ,
  (key eng. msg.) dest= 20.20.20.21, SRC= 20.20.20.20,
    dest_proxy= 50.50.50.0/255.255.255.0/0/0,
    src_proxy= 60.60.60.0/255.255.255.0/0/0,
    protocol= AH, transform= ah-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0x1A0A1946(436869446), conn_id= 12, keysize= 0,
flags= 0x4
*Mar  1 00:31:14.375: IPSEC(initialize_sas): ,
  (key eng. msg.) SRC= 20.20.20.21, dest= 20.20.20.20,
    src_proxy= 50.50.50.0/255.255.255.0/0/0,
    dest_proxy= 60.60.60.0/255.255.255.0/0/0,
    protocol= AH, transform= ah-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0x2C40706(46401286), conn_id= 13, keysize= 0,
flags= 0x4
*Mar  1 00:31:14.383: IPSEC(initialize_sas): ,
  (key eng. msg.) dest= 20.20.20.21, SRC= 20.20.20.20,
    dest_proxy= 50.50.50.0/255.255.255.0/0/0,
    src_proxy= 60.60.60.0/255.255.255.0/0/0,
    protocol= ESP, transform= esp-des esp-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0x11060F0C(285609740), conn_id= 14, keysize= 0,
flags= 0x4
*Mar  1 00:31:14.391: IPSEC(initialize_sas): ,
  (key eng. msg.) SRC= 20.20.20.21, dest= 20.20.20.20,
    src_proxy= 50.50.50.0/255.255.255.0/0/0,
    dest_proxy= 60.60.60.0/255.255.255.0/0/0,
    protocol= ESP, transform= esp-des esp-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0x12881335(310907701), conn_id= 15, keysize= 0,
 flags= 0x4
*Mar  1 00:31:14.399: IPSEC(create_sa): sa created,
  (sa) sa_dest= 20.20.20.21, sa_prot= 51,
    sa_spi= 0x1A0A1946(436869446),
    sa_trans= ah-sha-hmac , sa_conn_id= 12
*Mar  1 00:31:14.407: IPSEC(create_sa): sa created,
  (sa) sa_dest= 20.20.20.20, sa_prot= 51,
    sa_spi= 0x2C40706(46401286),
    sa_trans= ah-sha-hmac , sa_conn_id= 13
*Mar  1 00:31:14.411: IPSEC(create_sa): sa created,
  (sa) sa_dest= 20.20.20.21, sa_prot= 50,
    sa_spi= 0x11060F0C(285609740),
    sa_trans= esp-des esp-sha-hmac , sa_conn_id= 14
*Mar  1 00:31:14.415: IPSEC(create_sa): sa created,
  (sa) sa_dest= 20.20.20.20, sa_prot= 50,
    sa_spi= 0x12881335(310907701),
    sa_trans= esp-des esp-sha-hmac , sa_conn_id= 15
wan2511#
```

Sample 3: ISAKMP: RSA−SIG Authentication/CA

This example uses RSA signatures, which require the use of a CA server. Each peer obtains certificates from the CA server (this is usually a workstation that is configured to issue certificates). When both peers have valid CA certificates, they automatically exchange RSA public keys with each other as part of ISAKMP negotiation. All that is required in this scenario is for each peer to have registered with a CA and obtained a certificate. A peer no longer needs to keep public RSA keys of all the peers in a network.

Also, notice that an ISAKMP policy is not specified because you are using the default policy, which is shown below:

```
lab-isdn1#show crypto isakmp policy
Default protection suite
        encryption algorithm:   DES − Data Encryption Standard (56 bit keys).
        hash algorithm:         Secure Hash Standard
        authentication method:  Rivest−Shamir−Adleman Signature
        Diffie−Hellman group:   #1 (768 bit)
        lifetime:               86400 seconds, no volume limit
```

First, define the CA server's hostname, and generate the RSA key.

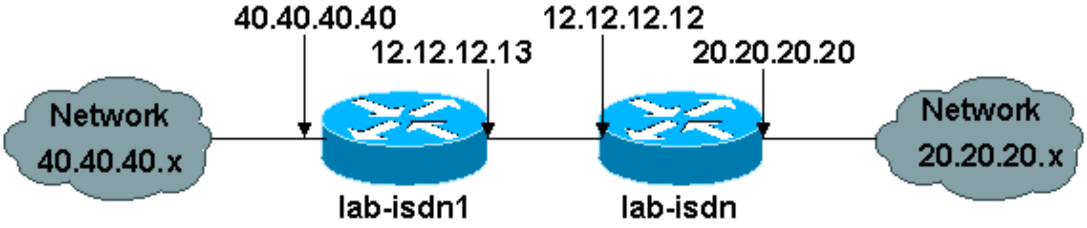
```
test1−isdn(config)#ip host cert−author 10.19.54.46
test1−isdn(config)#crypto key gen rsa usage
The name for the keys will be: test1−isdn.cisco.com
Choose the size of the key modulus in the range of 360 to 2048 for your
  Signature Keys. Choosing a key modulus greater than 512 may take
  a few minutes.

How many bits in the modulus [512]:
Generating RSA keys ...
[OK]
Choose the size of the key modulus in the range of 360 to 2048 for your
  Encryption Keys. Choosing a key modulus greater than 512 may take
  a few minutes.

How many bits in the modulus [512]:
Generating RSA keys ...
[OK]
```

Next, the CA configuration is defined with a tag called "test1−isdn−ultra" and defines the CA name URL. Then, authenticate with the CA server and obtain a certificate. Finally, keep checking to make sure you have received "Available" certificates for use.

```
test1−isdn(config)#crypto ca identity test1−isdn−ultra
test1−isdn(ca−identity)#enrollment url http://cert−author
test1−isdn(ca−identity)#crl optional
test1−isdn(ca−identity)#exit

−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−
test1−isdn(config)#crypto ca authenticate test1−isdn−ultra
Certificate has the following attributes:
Fingerprint: 71CA5A98 78828EF8 4987BA95 57830E5F
% Do you accept this certificate? [yes/no]: yes
Apr  3 14:08:56.329: CRYPTO_PKI: http connection opened
Apr  3 14:08:56.595: CRYPTO__PKI: All enrollment requests completed.
Apr  3 14:08:56.599: CRYPTO_PKI: transaction GetCACert completed
Apr  3 14:08:56.599: CRYPTO_PKI: CA certificate received
test1−isdn(config)#

−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−
test1−isdn(config)#crypto ca enroll test1−isdn−ultra
% Start certificate enrollment ..
% Create a challenge password. You will need to verbally provide this
   password to the CA Administrator in order to revoke your certificate.
   For security reasons your password will not be saved in the configuration.
   Please make a note of it.

Password:
Re−enter password:

% The subject name in the certificate will be: test1−isdn.cisco.com
% Include the router serial number in the subject name? [yes/no]: yes
% The serial number in the certificate will be: 04922418
% Include an IP address in the subject name? [yes/no]: yes
Interface: bri0
Request certificate from CA? [yes/no]: yes
% Certificate request sent to Certificate Authority
% The certificate request fingerprint will be displayed.
% The 'show crypto ca certificate' command will also show the fingerprint.

−−−−−−−−−−−−−−−−− status: pending −−−−−−−−−−−−−−−

test1−isdn#show crypto ca certificate
CA Certificate
  Status: Available
  Certificate Serial Number: 3051DF7169BEE31B821DFE4B3A338E5F
  Key Usage: Not Set

Certificate
  Subject Name
    Name: test1−isdn.cisco.com
    IP Address: 10.18.117.189
    Serial Number: 04922418
  Status: Pending
  Key Usage: Signature
    Fingerprint:  B1566229 472B1DDB 01A072C0 8202A985 00000000

Certificate
  Subject Name
    Name: test1−isdn.cisco.com
    IP Address: 10.18.117.189
    Serial Number: 04922418
  Status: Pending
  Key Usage: Encryption
```

```
    Fingerprint:  1EA39C07 D1B26FC7 7AD08BF4 ACA3AABD 00000000


------------------ status: available ----------------
test1-isdn#show crypto ca certificate
Certificate
  Subject Name
    Name: test1-isdn.cisco.com
    Serial Number: 04922418
  Status: Available
  Certificate Serial Number: 1BAFCBCA71F0434B59D192FAFB37D376
  Key Usage: Encryption

CA Certificate
  Status: Available
  Certificate Serial Number: 3051DF7169BEE31B821DFE4B3A338E5F
  Key Usage: Not Set

Certificate
  Subject Name
    Name: test1-isdn.cisco.com
    Serial Number: 04922418
  Status: Available
  Certificate Serial Number: 4B39EE2866814279CBA7534496DE1D99
  Key Usage: Signature

test1-isdn#
```

The following graphic represents the network diagram for this sample configuration.



The sample configuration below is taken from two Cisco 1600 routers that have previously obtained CA certificates (as shown above) and intend to do ISAKMP with "rsa−sig" as the authentication policy. Only traffic between the two remote Ethernet LANs is encrypted.

```
lab-isdn1#write terminal
Building configuration...

Current configuration:
!
version 11.3
service timestamps debug datetime msec
no service password-encryption
service udp-small-servers
service tcp-small-servers
!
hostname lab-isdn1
!
enable secret 5 $1$VdPY$uA/BIVeEm9UAFEm.PPJFc.
!
username lab-isdn password 0 cisco
ip host ciscoca-ultra 171.69.54.46
ip host lab-isdn 12.12.12.12
ip domain-name cisco.com
ip name-server 171.68.10.70
ip name-server 171.68.122.99
```

```
isdn switch−type basic−ni1
!
crypto ipsec transform−set mypolicy ah−sha−hmac esp−des esp−sha−hmac
!
crypto map test 10 ipsec−isakmp
 set peer 12.12.12.12
 set transform−set mypolicy
 match address 144
!
crypto ca identity bubba
 enrollment url http://ciscoca−ultra
 crl optional
crypto ca certificate chain bubba
 certificate 3E1ED472BDA2CE0163FB6B0B004E5EEE
  308201BC 30820166 A0030201 0202103E
 1ED472BD A2CE0163 FB6B0B00 4E5EEE30
  0D06092A 864886F7 0D010104 05003042
  31163014 06035504 0A130D43 6973636F
  20537973 74656D73 3110300E 06035504
  0B130744 65767465 73743116 30140603
  55040313 0D434953 434F4341 2D554C54
  5241301E 170D3938 30343038 30303030
  30305A17 0D393930 34303832 33353935
  395A303B 31273025 06092A86 4886F70D
  01090216 18737461 6E6E6F75 732D6973
  646E312E 63697363 6F2E636F 6D311030
  0E060355 04051307 35363739 39383730
  5C300D06 092A8648 86F70D01 01010500
  034B0030 48024100 D2D125FF BBFC6E56
  93CB4385 5473C165 BC7CCAF6 45C35BED
  554BAA0B 119AFA6F 0853F574 5E0B8492
  2E39B5FA 84C4DD05 C19AA625 8184395C
  6CBC7FA4 614F6177 02030100 01A33F30
  3D300B06 03551D0F 04040302 05203023
  0603551D 11041C30 1A821873 74616E6E
  6F75732D 6973646E 312E6369 73636F2E
  636F6D30 09060355 1D130402 3000300D
  06092A86 4886F70D 01010405 00034100
  04AF83B8 FE95F5D9 9C07C105 F1E88F1A
  9320CE7D 0FA540CF 44C77829 FC85C94B
  8CB4CA32 85FF9655 8E47AC9A B9D6BF1A
  0C4846DE 5CB07C8E A32038EC 8AFD161A
  quit
 certificate ca 3051DF7169BEE31B821DFE4B3A338E5F
  30820182 3082012C A0030201 02021030
  51DF7169 BEE31B82 1DFE4B3A 338E5F30
  0D06092A 864886F7 0D010104 05003042
  31163014 06035504 0A130D43 6973636F
  20537973 74656D73 3110300E 06035504
  0B130744 65767465 73743116 30140603
  55040313 0D434953 434F4341 2D554C54
  5241301E 170D3937 31323032 30313036
  32385A17 0D393831 32303230 31303632
  385A3042 31163014 06035504 0A130D43
  6973636F 20537973 74656D73 3110300E
  06035504 0B130744 65767465 73743116
  30140603 55040313 0D434953 434F4341
  2D554C54 5241305C 300D0609 2A864886
  F70D0101 01050003 4B003048 024100C1
  B69D7BF6 34E4EE28 A84E0DC6 FCA4DEA8
  04D89E50 C5EBE862 39D51890 D0D4B732
  678BDBF2 80801430 E5E56E7C C126E2DD
  DBE9695A DF8E5BA7 E67BAE87 29375302
  03010001 300D0609 2A864886 F70D0101
  04050003 410035AA 82B5A406 32489413
  A7FF9A9A E349E5B4 74615E05 058BA3CE
  7C5F00B4 019552A5 E892D2A3 86763A1F
  2852297F C68EECE1 F41E9A7B 2F38D02A
  B1D2F817 3F7B
  quit
 certificate 503968D890F7D409475B7280162754D2
  308201BC 30820166 A0030201 02021050
  3968D890 F7D40947 5B728016 2754D230
  0D06092A 864886F7 0D010104 05003042
  31163014 06035504 0A130D43 6973636F
  20537973 74656D73 3110300E 06035504
  0B130744 65767465 73743116 30140603
  55040313 0D434953 434F4341 2D554C54
  5241301E 170D3938 30343038 30303030
  30305A17 0D393930 34303832 33353935
  395A303B 31273025 06092A86 4886F70D
  01090216 18737461 6E6E6F75 732D6973
  646E312E 63697363 6F2E636F 6D311030
  0E060355 04051307 35363739 39383730
  5C300D06 092A8648 86F70D01 01010500
  034B0030 48024100 BECE2D8C B32E6B09
  0ADE0D46 AF8D4A1F 37850034 35D0C729
  3BF91518 0C9E4CF8 1A6A43AE E4F04687
  B8E2859D 33D5CE04 2E5DDEA6 3DA54A31
  2AD4255A 756014CB 02030100 01A33F30
  3D300B06 03551D0F 04040302 07803023
  0603551D 11041C30 1A821873 74616E6E
  6F75732D 6973646E 312E6369 73636F2E
  636F6D30 09060355 1D130402 3000300D
  06092A86 4886F70D 01010405 00034100
  B3AF6E71 CBD9AEDD A4711B71 6897F2CE
  D669A23A EE47B92B B2BE942A 422DF4A5
  7ACB9433 BD17EC7A BB3721EC E7D1175F
  5C62BC58 C409F805 19691FBD FD925138
  quit
!
interface Ethernet0
 ip address 40.40.40.40 255.255.255.0
 no ip mroute-cache
!
interface BRI0
 ip address 12.12.12.13 255.255.255.0
 encapsulation ppp
 no ip mroute-cache
 dialer idle-timeout 99999
 dialer map ip 12.12.12.12 name lab-isdn 4724171
 dialer hold-queue 40
 dialer-group 1
 isdn spid1 919472411800 4724118
 isdn spid2 919472411901 4724119
 ppp authentication chap
 crypto map test
!
ip classless
ip route 0.0.0.0 0.0.0.0 12.12.12.12
access-list 144 permit ip 40.40.40.0 0.0.0.255 20.20.20.0 0.0.0.255
dialer-list 1 protocol ip permit
!
line con 0
 exec-timeout 0 0
line vty 0 4
 password ww
 login
!
end

lab-isdn1#
```

```
------------------

lab-isdn#write terminal
Building configuration...

Current configuration:
!
version 11.3
service timestamps debug datetime msec
no service password-encryption
service udp-small-servers
service tcp-small-servers
!
hostname lab-isdn
!
enable secret 5 $1$oNe1$wDbhBdcN6x9Y5gfuMjqh10
!
username lab-isdn1 password 0 cisco
ip host ciscoca-ultra 171.69.54.46
ip host lab-isdn1 12.12.12.13
ip domain-name cisco.com
ip name-server 171.68.10.70
ip name-server 171.68.122.99
isdn switch-type basic-ni1
!
crypto ipsec transform-set mypolicy ah-sha-hmac
 esp-des esp-sha-hmac
!
crypto map test 10 ipsec-isakmp
 set peer 12.12.12.13
 set transform-set mypolicy
 match address 133
!
crypto ca identity lab
 enrollment url http://ciscoca-ultra
 crl optional
crypto ca certificate chain lab
 certificate 44FC6C531FC3446927E4EE307A806B20
  308201E0 3082018A A0030201 02021044
  FC6C531F C3446927 E4EE307A 806B2030
  0D06092A 864886F7 0D010104 05003042
  31163014 06035504 0A130D43 6973636F
  20537973 74656D73 3110300E 06035504
  0B130744 65767465 73743116 30140603
  55040313 0D434953 434F4341 2D554C54
  5241301E 170D3938 30343038 30303030
  30305A17 0D393930 34303832 33353935
  395A305A 31263024 06092A86 4886F70D
  01090216 17737461 6E6E6F75 732D6973
  646E2E63 6973636F 2E636F6D 311E301C
  060A2B06 0104012A 020B0201 130E3137
  312E3638 2E313137 2E313839 3110300E
  06035504 05130735 36373939 3139305C
  300D0609 2A864886 F70D0101 01050003
  4B003048 024100B8 F4A17A70 FAB5C2E3
  39186513 486779C7 61EF0AC1 3B6CFF83
  810E6D28 B3E4C034 CD803CFF 5158C270
  28FEBCDE CB6EF2D4 83BDD9B3 EAF915DB
  78266E96 500CD702 03010001 A3443042
  300B0603 551D0F04 04030205 20302806
  03551D11 0421301F 82177374 616E6E6F
  75732D69 73646E2E 63697363 6F2E636F
  6D8704AB 4475BD30 09060355 1D130402
  3000300D 06092A86 4886F70D 01010405
  00034100 BF65B931 0F960195 ABDD41D5
  622743D9 C12B5499 B3A8EB30 5005E6CC
  7FDF7C5B 51D13EB8 D46187E5 A1E7F711
  AEB7B33B AA4C6728 7A4BA692 00A44A05 C5CF973F
  quit
 certificate ca 3051DF7169BEE31B821DFE4B3A338E5F
  30820182 3082012C A0030201 02021030
  51DF7169 BEE31B82 1DFE4B3A 338E5F30
  0D06092A 864886F7 0D010104 05003042
  31163014 06035504 0A130D43 6973636F
  20537973 74656D73 3110300E 06035504
  0B130744 65767465 73743116 30140603
  55040313 0D434953 434F4341 2D554C54
  5241301E 170D3937 31323032 30313036
  32385A17 0D393831 32303230 31303632
  385A3042 31163014 06035504 0A130D43
  6973636F 20537973 74656D73 3110300E
  06035504 0B130744 65767465 73743116
  30140603 55040313 0D434953 434F4341
  2D554C54 5241305C 300D0609 2A864886
  F70D0101 01050003 4B003048 024100C1
  B69D7BF6 34E4EE28 A84E0DC6 FCA4DEA8
  04D89E50 C5EBE862 39D51890 D0D4B732
  678BDBF2 80801430 E5E56E7C C126E2DD
  DBE9695A DF8E5BA7 E67BAE87 29375302
  03010001 300D0609 2A864886 F70D0101
  04050003 410035AA 82B5A406 32489413
  A7FF9A9A E349E5B4 74615E05 058BA3CE
  7C5F00B4 019552A5 E892D2A3 86763A1F
  2852297F C68EECE1 F41E9A7B 2F38D02A
  B1D2F817 3F7B
  quit
 certificate 52A46D5D10B18A6F51E6BC735A36508C
  308201E0 3082018A A0030201 02021052
  A46D5D10 B18A6F51 E6BC735A 36508C30
  0D06092A 864886F7 0D010104 05003042
  31163014 06035504 0A130D43 6973636F
  20537973 74656D73 3110300E 06035504
  0B130744 65767465 73743116 30140603
  55040313 0D434953 434F4341 2D554C54
  5241301E 170D3938 30343038 30303030
  30305A17 0D393930 34303832 33353935
  395A305A 31263024 06092A86 4886F70D
  01090216 17737461 6E6E6F75 732D6973
  646E2E63 6973636F 2E636F6D 311E301C
  060A2B06 0104012A 020B0201 130E3137
  312E3638 2E313137 2E313839 3110300E
  06035504 05130735 36373939 3139305C
  300D0609 2A864886 F70D0101 01050003
  4B003048 024100D7 71AD5672 B487A019
  5ECD1954 6F919A3A 6270102E 5A9FF4DC
  7A608480 FB27A181 715335F4 399D3E57
  7F72B323 BF0620AB 60C371CF 4389BA4F
  C60EE6EA 21E06302 03010001 A3443042
  300B0603 551D0F04 04030207 80302806
  03551D11 0421301F 82177374 616E6E6F
  75732D69 73646E2E 63697363 6F2E636F
  6D8704AB 4475BD30 09060355 1D130402
  3000300D 06092A86 4886F70D 01010405
  00034100 8AD45375 54803CF3 013829A8
  8DB225A8 25342160 94546F3C 4094BBA3
  F2F5A378 97E2F06F DCFFC509 A07B930A
  FBE6C3CA E1FC7FD9 1E69B872 C402E62A A8814C09
  quit
!
interface Ethernet0
 ip address 20.20.20.20 255.255.255.0
```

```
!
interface BRI0
 description bri to rtp
 ip address 12.12.12.12 255.255.255.0
 no ip proxy-arp
 encapsulation ppp
 no ip mroute-cache
 bandwidth 128
 load-interval 30
 dialer idle-timeout 99999
 dialer hold-queue 40
 dialer-group 1
 isdn spid1 919472417100 4724171
 isdn spid2 919472417201 4724172
 ppp authentication chap
 crypto map test
!
ip classless
ip route 0.0.0.0 0.0.0.0 12.12.12.13
access-list 133 permit ip 20.20.20.0 0.0.0.255
 40.40.40.0 0.0.0.255
dialer-list 1 protocol ip permit
!
line con 0
 exec-timeout 0 0
line vty 0 4
 password ww
 login
!
end

lab-isdn#

------------------ RSA-sig ---------------------------
lab-isdn#show debug
Cryptographic Subsystem:
  Crypto ISAKMP debugging is on
  Crypto Engine debugging is on
  Crypto IPSEC debugging is on
lab-isdn#

lab-isdn#
*Mar 21 20:16:50.871: ISAKMP (4): processing SA payload.
 message ID = 0
*Mar 21 20:16:50.871: ISAKMP (4): Checking ISAKMP transform 1
 against priority 65535
        policy
*Mar 21 20:16:50.875: ISAKMP: encryption DES-CBC
*Mar 21 20:16:50.875: ISAKMP: hash SHA
*Mar 21 20:16:50.875: ISAKMP: default group 1
*Mar 21 20:16:50.875: ISAKMP:  auth RSA sig
*Mar 21 20:16:50.879: ISAKMP (4): atts are acceptable.
 Next payload is 0
*Mar 21 20:16:50.879: Crypto engine 0: generate
 alg param

*Mar 21 20:16:54.070: CRYPTO_ENGINE: Dh phase 1
status: 0
*Mar 21 20:16:54.090: ISAKMP (4): SA is doing RSA
 signature authentication
*Mar 21 20:16:57.343: ISAKMP (4): processing KE
 payload. message ID = 0
*Mar 21 20:16:57.347: Crypto engine 0: generate alg param

*Mar 21 20:17:01.168: ISAKMP (4): processing NONCE
payload. message ID = 0
```

```
*Mar 21 20:17:01.176: Crypto engine 0: create ISAKMP
 SKEYID for conn id 4
*Mar 21 20:17:01.188: ISAKMP (4): SKEYID state generated
*Mar 21 20:17:07.331: ISAKMP (4): processing ID
 payload. message ID = 0
*Mar 21 20:17:07.331: ISAKMP (4): processing CERT
 payload. message ID = 0
*Mar 21 20:17:07.497: ISAKMP (4): cert approved
 with warning
*Mar 21 20:17:07.600: ISAKMP (4): processing SIG
 payload. message ID = 0
*Mar 21 20:17:07.608: Crypto engine 0: RSA decrypt
 with public key
*Mar 21 20:17:07.759: generate hmac context for
 conn id 4
*Mar 21 20:17:07.767: ISAKMP (4): SA has been
 authenticated
*Mar 21 20:17:07.775: generate hmac context for
 conn id 4
*Mar 21 20:17:07.783: Crypto engine 0: RSA encrypt
 with private key
*Mar 21 20:17:08.672: CRYPTO_ENGINE: key process
 suspended and continued
*Mar 21 20:17:08.878: CRYPTO_ENGINE: key process
 suspended and continued
*Mar 21 20:17:09.088: CRYPTO_ENGINE: key process
 suspended and continued
*Mar 21 20:17:09.291: CRYPTO_ENGINE: key process
 suspended and continued
*Mar 21 20:17:09.493: CRYPTO_ENGINE: key process
 suspended and continued
*Mar 21 20:17:09.795: CRYPTO_ENGINE: key process
 suspended and continued
*Mar 21 20:17:10.973: generate hmac context for
 conn id 4
*Mar 21 20:17:10.981: ISAKMP (4): processing SA
 payload. message ID = −538880964
*Mar 21 20:17:10.981: ISAKMP (4): Checking IPSec proposal 1
*Mar 21 20:17:10.981: ISAKMP: transform 1, AH_SHA_HMAC
*Mar 21 20:17:10.985: ISAKMP: attributes in transform:
*Mar 21 20:17:10.985: ISAKMP: encaps is 1
*Mar 21 20:17:10.985: ISAKMP: SA life type in seconds
*Mar 21 20:17:10.985: ISAKMP: SA life duration (basic) of 3600
*Mar 21 20:17:10.989: ISAKMP: SA life type in kilobytes
*Mar 21 20:17:10.989: ISAKMP: SA life duration (VPI) of
  0x0 0x46 0x50 0x0
*Mar 21 20:17:10.993: ISAKMP (4): atts are acceptable.
*Mar 21 20:17:10.993: ISAKMP (4): Checking IPSec proposal 1
*Mar 21 20:17:10.993: ISAKMP: transform 1, ESP_DES
*Mar 21 20:17:10.997: ISAKMP: attributes in transform:
*Mar 21 20:17:10.997: ISAKMP: encaps is 1
*Mar 21 20:17:10.997: ISAKMP: SA life type in seconds
*Mar 21 20:17:10.997: ISAKMP: SA life duration (basic) of 3600
*Mar 21 20:17:11.001: ISAKMP: SA life type in kilobytes
*Mar 21 20:17:11.001: ISAKMP: SA life duration (VPI) of
  0x0 0x46 0x50 0x0
*Mar 21 20:17:11.001: ISAKMP: HMAC algorithm is SHA
*Mar 21 20:17:11.005: ISAKMP (4): atts are acceptable.
*Mar 21 20:17:11.005: IPSEC(validate_proposal_request):
 proposal part #1,
  (key eng. msg.) dest= 12.12.12.12, SRC= 12.12.12.13,
    dest_proxy= 20.20.20.0/0.0.0.0/0/0,
    src_proxy= 40.40.40.0/0.0.0.16/0/0,
    protocol= AH, transform= ah−sha−hmac ,
    lifedur= 0s and 0kb,
    spi= 0x0(0), conn_id= 0, keysize= 0, flags= 0x4
```

```
*Mar 21 20:17:11.013: IPSEC(validate_proposal_request):
 proposal part #2,
  (key eng. msg.) dest= 12.12.12.12, SRC= 12.12.12.13,
    dest_proxy= 20.20.20.0/0.0.0.0/0/0,
    src_proxy= 40.40.40.0/0.0.0.16/0/0,
    protocol= ESP, transform= esp-des esp-sha-hmac ,
    lifedur= 0s and 0kb,
    spi= 0x0(0), conn_id= 0, keysize= 0, flags= 0x4
*Mar 21 20:17:11.021: ISAKMP (4): processing NONCE payload.
  message ID = -538880964
*Mar 21 20:17:11.021: ISAKMP (4): processing ID payload.
  message ID = -538880964
*Mar 21 20:17:11.021: ISAKMP (4): processing ID payload.
 message ID = -538880964
*Mar 21 20:17:11.025: IPSEC(key_engine):
got a queue event...
*Mar 21 20:17:11.029: IPSEC(spi_response):
getting spi 112207019 for SA
        from 12.12.12.13     to 12.12.12.12 for prot 2
*Mar 21 20:17:11.033: IPSEC(spi_response):
getting spi 425268832 for SA
        from 12.12.12.13     to 12.12.12.12 for prot 3
*Mar 21 20:17:11.279: generate hmac context for conn id 4
*Mar 21 20:17:11.612: generate hmac context for conn id 4
*Mar 21 20:17:11.644: ISAKMP (4): Creating IPSec SAs
*Mar 21 20:17:11.644:         inbound SA from
12.12.12.13 to 12.12.12.12
        (proxy 40.40.40.0      to 20.20.20.0     )
*Mar 21 20:17:11.648:         has spi 112207019
and conn_id 5 and flags 4
*Mar 21 20:17:11.648:         lifetime of 3600 seconds
*Mar 21 20:17:11.648:         lifetime of 4608000 kilobytes
*Mar 21 20:17:11.652: outbound SA from 12.12.12.12 to 12.12.12.13
        (proxy 20.20.20.0  to 40.40.40.0     )
*Mar 21 20:17:11.652: has spi 83231845 and conn_id 6 and flags 4
*Mar 21 20:17:11.656: lifetime of 3600 seconds
*Mar 21 20:17:11.656: lifetime of 4608000 kilobytes
*Mar 21 20:17:11.656: ISAKMP (4): Creating IPSec SAs
*Mar 21 20:17:11.656:  inbound SA from 12.12.12.13 to 12.12.12.12
        (proxy 40.40.40.0      to 20.20.20.0     )
*Mar 21 20:17:11.660: has spi 425268832 and conn_id 7 and flags 4
*Mar 21 20:17:11.660: lifetime of 3600 seconds
*Mar 21 20:17:11.664: lifetime of 4608000 kilobytes
*Mar 21 20:17:11.664: outbound SA from 12.12.12.12 to 12.12.12.13
        (proxy 20.20.20.0 to 40.40.40.0     )
*Mar 21 20:17:11.668: has spi 556010247 and conn_id 8 and flags 4
*Mar 21 20:17:11.668: lifetime of 3600 seconds
*Mar 21 20:17:11.668: lifetime of 4608000 kilobytes
*Mar 21 20:17:11.676: IPSEC(key_engine): got a queue event...
*Mar 21 20:17:11.676: IPSEC(initialize_sas): ,
  (key eng. msg.) dest= 12.12.12.12, SRC= 12.12.12.13,
    dest_proxy= 20.20.20.0/255.255.255.0/0/0,
    src_proxy= 40.40.40.0/255.255.255.0/0/0,
    protocol= AH, transform= ah-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0x6B024AB(112207019), conn_id= 5, keysize= 0, flags= 0x4
*Mar 21 20:17:11.680: IPSEC(initialize_sas): ,
  (key eng. msg.) SRC= 12.12.12.12, dest= 12.12.12.13,
    src_proxy= 20.20.20.0/255.255.255.0/0/0,
    dest_proxy= 40.40.40.0/255.255.255.0/0/0,
    protocol= AH, transform= ah-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0x4F60465(83231845), conn_id= 6, keysize= 0, flags= 0x4
*Mar 21 20:17:11.687: IPSEC(initialize_sas): ,
  (key eng. msg.) dest= 12.12.12.12, SRC= 12.12.12.13,
    dest_proxy= 20.20.20.0/255.255.255.0/0/0,
    src_proxy= 40.40.40.0/255.255.255.0/0/0,
    protocol= ESP, transform= esp-des esp-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0x19591660(425268832), conn_id= 7, keysize= 0, flags= 0x4
*Mar 21 20:17:11.691: IPSEC(initialize_sas): ,
  (key eng. msg.) SRC= 12.12.12.12, dest= 12.12.12.13,
    src_proxy= 20.20.20.0/255.255.255.0/0/0,
    dest_proxy= 40.40.40.0/255.255.255.0/0/0,
    protocol= ESP, transform= esp-des esp-sha-hmac ,
    lifedur= 3600s and 4608000kb,
    spi= 0x21240B07(556010247), conn_id= 8, keysize= 0, flags= 0x4
*Mar 21 20:17:11.699: IPSEC(create_sa): sa created,
  (sa) sa_dest= 12.12.12.12, sa_prot= 51,
    sa_spi= 0x6B024AB(112207019),
    sa_trans= ah-sha-hmac , sa_conn_id= 5
*Mar 21 20:17:11.703: IPSEC(create_sa): sa created,
  (sa) sa_dest= 12.12.12.13, sa_prot= 51,
    sa_spi= 0x4F60465(83231845),
    sa_trans= ah-sha-hmac , sa_conn_id= 6
*Mar 21 20:17:11.707: IPSEC(create_sa): sa created,
  (sa) sa_dest= 12.12.12.12, sa_prot= 50,
    sa_spi= 0x19591660(425268832),
    sa_trans= esp-des esp-sha-hmac , sa_conn_id= 7
*Mar 21 20:17:11.707: IPSEC(create_sa): sa created,
  (sa) sa_dest= 12.12.12.13, sa_prot= 50,
    sa_spi= 0x21240B07(556010247),
    sa_trans= esp-des esp-sha-hmac , sa_conn_id= 8
*Mar 21 20:18:06.767: ISADB: reaper checking SA, conn_id = 4
lab-isdn#
```

Troubleshooting for IPSec and ISAKMP

It is generally best to begin each troubleshooting session by gathering information using the following commands. An asterisk (*) indicates an especially useful command. Please also see IP Security Troubleshooting − Understanding and Using debug Commands for additional information.

Certain **show** commands are supported by the Output Interpreter Tool (registered customers only) , which allows you to view an analysis of **show** command output.

Note: Before issuing **debug** commands, please see Important Information on Debug Commands.

Commands	
debug crypto pki trans	* **debug crypto ipsec**
* **debug crypto isakmp**	**debug crypto key**
debug crypto sess	**debug crypto engine**
show crypto engine connections active	**show crypto engine connections dropped−packet**
show crypto engine configuration	* **show crypto ca certificates**
* **show crypto key mypubkey rsa**	* **show crypto key pubkey−chain rsa**
show crypto isakmp policy	**show crypto isakmp sa**
show crypto ipsec sa	**show crypto ipsec session−key**
show crypto ipsec	**show crypto map interface bri**

transform−proposal	**0**
show crypto map tag test	**clear crypto connection <connection id of SA>**
*** clear crypto isakmp**	*** clear crypto sa**
clear crypto sa counters	**clear crypto sa map**
clear crypto sa peer	**clear crypto sa spi**
clear crypto sa counters	

Sample output from some of these commands is shown below.

```
wan2511#show crypto engine connections active
ID    Interface       IP−Address  State  Algorithm       Encrypt  Decrypt
 9    Serial0         20.20.20.21 set    HMAC_SHA        0        240
 10   Serial0         20.20.20.21 set    HMAC_SHA        240      0

wan2511#show crypto engine connections dropped−packet
Interface            IP−Address    Drop Count

wan2511#show crypto engine configuration
slot:               0
engine name:        unknown
engine type:        software
serial number:      01496536
platform:           rp crypto engine
crypto lib version: 10.0.0

Encryption Process Info:
input queue top:    140
input queue bot:    140
input queue count:  0

wan2511#show crypto key mypubkey rsa
% Key pair was generated at: 00:09:04 UTC Mar 1 1993
Key name: wan2511.cisco.com
Usage:    General Purpose Key
Key Data:
 305C300D 06092A86 4886F70D 01010105
00034B00 30480241 00E9007B E5CD7DC8
 6E1C0423 92044254 92C972AD 0CCE9796
86797EAA B6C4EFF0 0F0A5378 6AFAE43B
 3A2BD92F 98039DAC 08741E82 5D9053C4
D9CFABC1 AB54E0E2 BB020301 0001

wan2511#show crypto key pubkey−chain rsa
wan2511#

wan2511#show crypto isakmp policy
Protection suite of priority 1
        encryption algorithm:   DES − Data Encryption Standard (56 bit keys).
        hash algorithm:         Secure Hash Standard
        authentication method:  Pre−Shared Key
        Diffie−Hellman group:   #2 (1024 bit)
        lifetime:               240 seconds, no volume limit
Default protection suite
        encryption algorithm:   DES − Data Encryption Standard (56 bit keys).
        hash algorithm:         Secure Hash Standard
        authentication method:  Rivest−Shamir−Adleman Signature
        Diffie−Hellman group:   #1 (768 bit)
        lifetime:               86400 seconds, no volume limit
wan2511#show crypto isakmp sa
    dst            src          state         conn−id   slot
```

```
20.20.20.21    20.20.20.20    QM_IDLE           7       0

wan2511#
wan2511#show crypto ipsec sa

interface: Serial0
    Crypto map tag: test, local addr. 20.20.20.21

   local  ident (addr/mask/prot/port): (50.50.50.0/255.255.255.0/0/0)
   remote ident (addr/mask/prot/port): (60.60.60.0/255.255.255.0/0/0)
   current_peer: 20.20.20.20
     PERMIT, flags={origin_is_acl,ident_is_ipsec,}
    #pkts encaps: 320, #pkts encrypt: 320, #pkts digest 320
    #pkts decaps: 320, #pkts decrypt: 320, #pkts verify 320
    #send errors 0, #recv errors 0

     local crypto endpt.: 20.20.20.21, remote crypto endpt.: 20.20.20.20
     path mtu 1500, media mtu 1500
     current outbound spi: 6625CD

     inbound esp sas:
      spi: 0x1925112F(421859631)
        transform: esp-des esp-sha-hmac ,
        in use settings ={Tunnel, }
        slot: 0, conn id: 11, crypto map: test
        sa timing: remaining key lifetime (k/sec): (4607971/3354)
        IV size: 8 bytes
        replay detection support: Y


     inbound ah sas:
      spi: 0x12050DD2(302321106)
        transform: ah-sha-hmac ,
        in use settings ={Tunnel, }
        slot: 0, conn id: 9, crypto map: test
        sa timing: remaining key lifetime (k/sec): (4607958/3354)
        replay detection support: Y


     outbound esp sas:
      spi: 0x3262313(52830995)
        transform: esp-des esp-sha-hmac ,
        in use settings ={Tunnel, }
        slot: 0, conn id: 12, crypto map: test
        sa timing: remaining key lifetime (k/sec): (4607971/3354)
        IV size: 8 bytes
        replay detection support: Y


     outbound ah sas:
      spi: 0x6625CD(6694349)
        transform: ah-sha-hmac ,
        in use settings ={Tunnel, }
        slot: 0, conn id: 10, crypto map: test
        sa timing: remaining key lifetime (k/sec): (4607958/3354)
        replay detection support: Y

wan2511#show crypto ipsec session-key
Session key lifetime: 4608000 kilobytes/3600 seconds

wan2511#show crypto ipsec transform-proposal
Transform proposal auth2: { ah-sha-hmac  }
   supported settings = { Tunnel,  },
   default settings = { Tunnel,  },
   will negotiate = { Tunnel,  },
   { esp-des esp-sha-hmac  }
   supported settings = { Tunnel,  },
   default settings = { Tunnel,  },
   will negotiate = { Tunnel,  },


wan2511#show crypto map interface serial 0
Crypto Map "test" 10 ipsec-isakmp
        Peer = 20.20.20.20
        Extended IP access list 133
            access-list 133 permit ip
                source: addr = 50.50.50.0/0.0.0.255
                dest:   addr = 60.60.60.0/0.0.0.255
        Current peer: 20.20.20.20
        Session key lifetime: 4608000 kilobytes/3600 seconds
        PFS (Y/N): N
        Transform proposals={ auth2, }

wan2511#show crypto map tag test
Crypto Map "test" 10 ipsec-isakmp
        Peer = 20.20.20.20
        Extended IP access list 133
            access-list 133 permit ip
                source: addr = 50.50.50.0/0.0.0.255
                dest:   addr = 60.60.60.0/0.0.0.255
        Current peer: 20.20.20.20
        Session key lifetime: 4608000 kilobytes/3600 seconds
        PFS (Y/N): N
        Transform proposals={ auth2, }

wan2511#

----------------------
lab-isdn1#show crypto engine connections active
ID    Interface       IP-Address  State  Algorithm       Encrypt  Decrypt
 5    BRI0            12.12.12.13 set    HMAC_SHA        0        89
 6    BRI0            12.12.12.13 set    HMAC_SHA        89       0

lab-isdn1#show crypto engine connections dropped-packet
Interface            IP-Address    Drop Count

BRI0                 12.12.12.13   4
lab-isdn1#show crypto engine configuration
slot:               0
engine name:        unknown
engine type:        software
serial number:      05679987
platform:           rp crypto engine
crypto lib version: 10.0.0

Encryption Process Info:
input queue top:    243
input queue bot:    243
input queue count:  0

lab-isdn1#show crypto ca cert
Certificate
  Subject Name
    Name: lab-isdn1.cisco.com
    Serial Number: 05679987
  Status: Available
  Certificate Serial Number: 3E1ED472BDA2CE0163FB6B0B004E5EEE
  Key Usage: Encryption

CA Certificate
  Status: Available
  Certificate Serial Number: 3051DF7169BEE31B821DFE4B3A338E5F
  Key Usage: Not Set

Certificate
  Subject Name
    Name: lab-isdn1.cisco.com
    Serial Number: 05679987
  Status: Available
  Certificate Serial Number: 503968D890F7D409475B7280162754D2
  Key Usage: Signature


lab-isdn1#show crypto key mypubkey rsa
% Key pair was generated at: 03:10:23 UTC Mar 21 1993
Key name: lab-isdn1.cisco.com
Usage:    Signature Key
Key Data:
 305C300D 06092A86 4886F70D 01010105
00034B00 30480241 00BECE2D 8CB32E6B
 090ADE0D 46AF8D4A 1F378500 3435D0C7
293BF915 180C9E4C F81A6A43 AEE4F046
 87B8E285 9D33D5CE 042E5DDE A63DA54A
312AD425 5A756014 CB020301 0001
% Key pair was generated at: 03:11:17 UTC Mar 21 1993
Key name: lab-isdn1.cisco.com
Usage:    Encryption Key
Key Data:
 305C300D 06092A86 4886F70D 01010105
00034B00 30480241 00D2D125 FFBBFC6E
 5693CB43 855473C1 65BC7CCA F645C35B
ED554BAA 0B119AFA 6F0853F5 745E0B84
 922E39B5 FA84C4DD 05C19AA6 25818439
5C6CBC7F A4614F61 77020301 0001

lab-isdn1#show crypto key pubkey-chain rsa
Key name: Cisco SystemsDevtestCISCOCA-ULTRA
Key serial number: C7040262
Key usage: signatures only
Key source: certificate
Key data:
 305C300D 06092A86 4886F70D 01010105
 00034B00 30480241 00C1B69D 7BF634E4
 EE28A84E 0DC6FCA4 DEA804D8 9E50C5EB
 E86239D5 1890D0D4 B732678B DBF28080
 1430E5E5 6E7CC126 E2DDDBE9 695ADF8E
 5BA7E67B AE872937 53020301 0001

Key name: lab-isdn.cisco.com
Key address: 171.68.117.189
Key serial number: 05679919
Key usage: general purpose
Key source: certificate
Key data:
 305C300D 06092A86 4886F70D 01010105
00034B00 30480241 00D771AD 5672B487
 A0195ECD 19546F91 9A3A6270 102E5A9F
F4DC7A60 8480FB27 A1817153 35F4399D
 3E577F72 B323BF06 20AB60C3 71CF4389
 BA4FC60E E6EA21E0 63020301 0001


lab-isdn1#show crypto isakmp policy
Default protection suite
        encryption algorithm:   DES - Data Encryption Standard (56 bit keys).
        hash algorithm:         Secure Hash Standard
        authentication method:  Rivest-Shamir-Adleman Signature
        Diffie-Hellman group:   #1 (768 bit)
        lifetime:               86400 seconds, no volume limit


lab-isdn1#show crypto isakmp sa
    dst           src           state        conn-id   slot
12.12.12.12    12.12.12.13    QM_IDLE           4       0


lab-isdn1#show crypto ipsec sa

interface: BRI0
    Crypto map tag: test, local addr. 12.12.12.13

   local  ident (addr/mask/prot/port): (40.40.40.0/255.255.255.0/0/0)
   remote ident (addr/mask/prot/port): (20.20.20.0/255.255.255.0/0/0)
   current_peer: 12.12.12.12
     PERMIT, flags={origin_is_acl,ident_is_ipsec,}
    #pkts encaps: 89, #pkts encrypt: 89, #pkts digest 89
    #pkts decaps: 89, #pkts decrypt: 89, #pkts verify 89
    #send errors 11, #recv errors 0

     local crypto endpt.: 12.12.12.13, remote crypto endpt.: 12.12.12.12
     path mtu 1500, media mtu 1500
     current outbound spi: 6B024AB

     inbound esp sas:
      spi: 0x21240B07(556010247)
        transform: esp-des esp-sha-hmac ,
        in use settings ={Tunnel, }
        slot: 0, conn id: 7, crypto map: test
        sa timing: remaining key lifetime (k/sec): (4607989/3062)
        IV size: 8 bytes
        replay detection support: Y


     inbound ah sas:
      spi: 0x4F60465(83231845)
        transform: ah-sha-hmac ,
        in use settings ={Tunnel, }
        slot: 0, conn id: 5, crypto map: test
        sa timing: remaining key lifetime (k/sec): (4607984/3062)
        replay detection support: Y


     outbound esp sas:
      spi: 0x19591660(425268832)
        transform: esp-des esp-sha-hmac ,
        in use settings ={Tunnel, }
        slot: 0, conn id: 8, crypto map: test
        sa timing: remaining key lifetime (k/sec): (4607989/3062)
        IV size: 8 bytes
        replay detection support: Y


     outbound ah sas:
      spi: 0x6B024AB(112207019)
        transform: ah-sha-hmac ,
        in use settings ={Tunnel, }
        slot: 0, conn id: 6, crypto map: test
        sa timing: remaining key lifetime (k/sec): (4607984/3062)
        replay detection support: Y


lab-isdn1#show crypto ipsec session-key
Session key lifetime: 4608000 kilobytes/3600 seconds
```

```
lab-isdn1#show crypto ipsec transform-proposal
Transform proposal mypolicy: { ah-sha-hmac  }
   supported settings = { Tunnel,  },
   default settings = { Tunnel,  },
   will negotiate = { Tunnel,  },

   { esp-des esp-sha-hmac  }
   supported settings = { Tunnel,  },
   default settings = { Tunnel,  },
   will negotiate = { Tunnel,  },


lab-isdn1#show crypto map interface bri 0
Crypto Map "test" 10 ipsec-isakmp
        Peer = 12.12.12.12
        Extended IP access list 144
            access-list 144 permit ip
                source: addr = 40.40.40.0/0.0.0.255
                dest:   addr = 20.20.20.0/0.0.0.255
        Current peer: 12.12.12.12
        Session key lifetime: 4608000 kilobytes/3600 seconds
        PFS (Y/N): N
        Transform proposals={ mypolicy, }


lab-isdn1#show crypto map tag test
Crypto Map "test" 10 ipsec-isakmp
        Peer = 12.12.12.12
        Extended IP access list 144
            access-list 144 permit ip
                source: addr = 40.40.40.0/0.0.0.255
                dest:   addr = 20.20.20.0/0.0.0.255
        Current peer: 12.12.12.12
        Session key lifetime: 4608000 kilobytes/3600 seconds
        PFS (Y/N): N
        Transform proposals={ mypolicy, }

lab-isdn1#

----------------------------
lab-isdn1#clear crypto isakmp
lab-isdn1#
*Mar 21 20:58:34.503: ISADB: reaper checking SA, conn_id = 4  DELETE IT!
*Mar 21 20:58:34.507: generate hmac context for conn id 4
*Mar 21 20:58:34.519: CRYPTO(epa_release_crypto_conn_entry): released conn 4
lab-isdn1#
lab-isdn1#clear crypto sa
lab-isdn1#
*Mar 21 20:58:42.495: IPSEC(delete_sa): deleting SA,
  (sa) sa_dest= 12.12.12.13, sa_prot= 51,
    sa_spi= 0x4F60465(83231845),
    sa_trans= ah-sha-hmac , sa_conn_id= 5
*Mar 21 20:58:42.499: CRYPTO(epa_release_crypto_conn_entry): released conn 5
*Mar 21 20:58:42.499: IPSEC(delete_sa): deleting SA,
  (sa) sa_dest= 12.12.12.12, sa_prot= 51,
    sa_spi= 0x6B024AB(112207019),
    sa_trans= ah-sha-hmac , sa_conn_id= 6
*Mar 21 20:58:42.503: CRYPTO(epa_release_crypto_conn_entry): released conn 6
*Mar 21 20:58:42.503: IPSEC(delete_sa): deleting SA,
  (sa) sa_dest= 12.12.12.13, sa_prot= 50,
    sa_spi= 0x21240B07(556010247),
    sa_trans= esp-des esp-sha-hmac , sa_conn_id= 7
*Mar 21 20:58:42.507: CRYPTO(epa_release_crypto_conn_entry): released conn 7
*Mar 21 20:58:42.507: IPSEC(delete_sa): deleting SA,
  (sa) sa_dest= 12.12.12.12, sa_prot= 50,
    sa_spi= 0x19591660(425268832),
    sa_trans= esp−des esp−sha−hmac , sa_conn_id= 8
*Mar 21 20:58:42.511: CRYPTO(epa_release_crypto_conn_entry): released conn 8
lab−isdn1#
```

Related Information

- **Configuring and Troubleshooting Cisco Network−Layer Encryption: Background − Part 1**
- **DES FIPS 46−2 at National Institute of Standards and Technology (NIST)**
- **DSS FIPS 186 at National Institute of Standards and Technology (NIST)**
- **RSA Laboratories' Frequently Asked Questions About Today's Cryptography**
- **IETF Security Standards**
- **Configuring Internet Key Exchange Security Protocol**
- **Configuring IPSec Network Security**
- **IPSec Support Page**
- **Technical Support − Cisco Systems**

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