Sx Over IPSec

Revision History

Note Revision history details are not provided for features introduced before release 21.24.

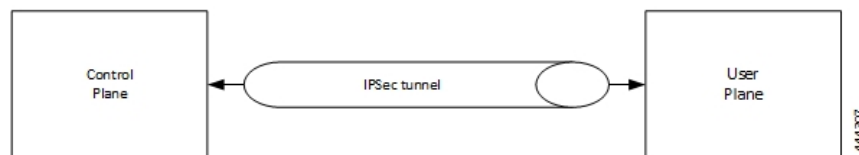| Revision Details	Release
First introduced	Pre 21.24

Feature Description

IPSec is a suite of protocols that interact with one another to provide secure private communications across IP networks. These protocols allow the system to establish and maintain secure tunnels with peer security gateways. IPSec provides confidentiality, data integrity, access control, and data source authentication to IP datagrams.

In CUPS, the functionality is available with IPSec in Tunnel mode both on Control Plane (CP) and User Plane (UP) nodes. The IPSec crypto-maps are associated under the appropriate interface on respective nodes. The IPSec tunnel is created between each CP or UP pair explicitly. There is no change that is required on Sx service configuration.

IPSec Tunnel Mode encapsulates the entire IP packet to provide a virtual secure hop between two gateways. It forms more familiar VPN kind of functionality, where entire IP packets are encapsulated inside another and delivered to the destination. It encapsulates the full IP header as well as the payload.

Figure 1: Sx Over IPSec tunnel

When Sx over IPSec is enabled on UP node running VPP, then following parameter must be used under "UPP Param" for Sx over IPSec feature to work.

VPP_DPDK_DATA_SIZE=5120

The UPP Param is stored in staros_para.cfg file on a CD-ROM and this configuration is read and applied to VPP by UP during its boot.

> **Note** This parameter introduces a memory overhead of about 800 MB. The user must consider this condition before using the feature. If the UP has less RAM, then VM must be allocated with extra 1 GB of RAM memory for the feature to work properly.

For more information on IPSec support, refer StarOS *IPSec Reference*.

IKEv2 Keep-Alive Messages (Dead Peer Detection)

IPSec for Sx interface supports IKEv2 keep-alive messages, also known as Dead Peer Detection (DPD), originating from both ends of an IPSec tunnel. Per RFC 3706, DPD is used to simplify the messaging required to verify communication between peers and tunnel availability.

IPSec DPD is an optional configuration. If its disabled, the IPSec node doesn't initiate DPD request. However, the node always responds to DPD availability messages initiated by peer node regardless of its DPD configuration.

The following method/formula can be used to calculate the keep-alive interval value when Sx over IPSec feature is configured:

```
((max-retransmissions + 1) * retransmission-timeout-ms) * 2
```

The keep-alive interval value specifies the time that the IPSec tunnel will remain up till DPD is triggered.

Example:

The following is a sample output for **show configuration context** *context_name* **verbose** CLI command under Sx service:

```
sx-service sx
   instance-type userplane
   bind ipv4-address 192.168.1.1 ipv6-address bbbb:abcd::11
   sxa max-retransmissions 4
   sxa retransmission-timeout-ms 5000
```

Here, the value of **max-retransmissions** is 4 and **retransmission-timeout-ms** is 5000. Therefore, the keep-alive interval value will be 50:

((max-retransmissions + 1) * retransmission-timeout-ms) * 2 = Keep-alive interval

((4+1) * 5000) * 2 = 50

IKESA Rekey

CUPS supports both IKESA Rekey and IPSec Rekey.

For IKESA Rekey, the **lifetime** *interval* CLI must be configured under **ikev2-ikesa transform-set** *transform_set*. You must also configure **ikev2-ikesa rekey** under **crypto map** configuration. Following is a configuration example:

```
ikev2-ikesa transform-set ikesa-foo
   encryption aes-cbc-256
   group 14
   hmac sha2-256-128
   lifetime 28800
   prf sha2-256
...
...
...
crypto map foo0 ikev2-ipv4
   match address foo0
   authentication local pre-shared-key encrypted key secret_key
   authentication remote pre-shared-key encrypted key secret_key
   ikev2-ikesa max-retransmission 3
   ikev2-ikesa retransmission-timeout 15000
   ikev2-ikesa transform-set list ikesa-foo
   ikev2-ikesa rekey
   keepalive interval 50
   control-dont-fragment clear-bit
   payload foo-sa0 match ipv4
      ipsec transform-set list A-foo
      lifetime 600
      rekey keepalive
   #exit
   peer 172.19.222.2
   ikev2-ikesa policy error-notification
```

Limitations

The following is the known limitation of Sx Over IPSec feature:

• The feature is supported only in IPv4-IPv4 tunneling mode.

Recommended Timers

The following table provides the recommended timer values for CLI commands related to IPSec, Sx, and SRP.

IPSEC	CP	UP
ikev2-ikesa max-retransmission	*3*	*3*
ikev2-ikesa retransmission-timeout	*1000*	*1000*
keepalive	**interval** *4* **timeout** *1* **num-retry** *4*	**interval** *5* **timeout** *2* **num-retry** *4*
Sx	**CP**	**UP**

IPSEC	CP	UP
sx-protocol heartbeat interval	*10*	*10*
sx-protocol heartbeat retransmission-timeout	*5*	*5*
sx-protocol heartbeat max-retransmissions	*4*	*4*
sxa max-retransmissions	*4*	*4*
sxa retransmission-timeout-ms	*5000*	*5000*
sxb max-retransmissions	*4*	*4*
sxb retransmission-timeout-ms	*5000*	*5000*
sxab max-retransmissions	*4*	*4*
sxab retransmission-timeout-ms	*5000*	*5000*
sx-protocol association reattempt-timeout	*60*	*60*
SRP	**CP**	**UP**
hello-interval	*3*	*3*
dead-interval	*15*	*15*

Recommended Configurations

Following are the recommended configurations and restrictions related to Sx and SRP over IPSec:

- The multihop BFD timer between CP and UP must be seven seconds (for Data UPs).

- The singlehop BFD must be enabled on all the contexts (CP GW/Billing and UP Gn/Gi).

- Inter-chassis multihop BFD must be enabled for CP-CP ICSR and UP-UP ICSR (IMS UP).

- The SRP-IPSec ACL must be configured for TCP protocol instead of IP protocol.

- The Sx-IPSec ACL must be configured for UDP protocol instead of IP protocol.

Example Configurations in CP

Multihop BFD Configuration VPC DI

The following is an example of multihop BFD configuration with seven seconds timer.

```
bfd-protocol
     bfd multihop-peer 192.1.1.1 interval 350 min_rx 350 multiplier 20
     bfd multihop-peer 192.1.2.1 interval 350 min_rx 350 multiplier 20
     bfd multihop-peer 192.1.0.1 interval 350 min_rx 350 multiplier 20
     bfd multihop-peer 192.1.6.1 interval 350 min_rx 350 multiplier 20
     bfd multihop-peer 192.1.3.1 interval 350 min_rx 350 multiplier 20
     bfd multihop-peer 192.1.4.1 interval 350 min_rx 350 multiplier 20
   #exit
```

Multihop BFD Configuration VPC SI

The following is an example of multihop BFD configuration with three seconds timer.

```
bfd-protocol
    bfd multihop-peer 192.1.1.1 interval 150 min_rx 150 multiplier 20
    bfd multihop-peer 192.1.2.1 interval 150 min_rx 150 multiplier 20
    bfd multihop-peer 192.1.0.1 interval 150 min_rx 150 multiplier 20
    bfd multihop-peer 192.1.6.1 interval 150 min_rx 150 multiplier 20
    bfd multihop-peer 192.1.3.1 interval 150 min_rx 150 multiplier 20
    bfd multihop-peer 192.1.4.1 interval 150 min_rx 150 multiplier 20
  #exit
```

BGP Configuration

The following is an example of BGP configuration with recommended timers.

```
router bgp 1111
    router-id 192.0.0.1
    maximum-paths ebgp 15
    neighbor 192.0.0.101 remote-as 1000
    neighbor 192.0.0.101 ebgp-multihop
    neighbor 192.0.0.101 update-source 192.0.0.1
    neighbor 1111:2222::101 remote-as 1000
    neighbor 1111:2222::101 ebgp-multihop
    neighbor 1111:2222::101 update-source 1111:2222::1
    bgp graceful-restart restart-time 120
    bgp graceful-restart stalepath-time 300
    timers bgp keepalive-interval 30 holdtime-interval 90 min-peer-holdtime-interval 0
server-sock-open-delay-period 10
    address-family ipv4
      redistribute connected
    #exit
    address-family ipv6
      neighbor 1111:2222::101 activate
      redistribute connected
    #exit
  #exit
```

Singlehop BFD Configuration

The following is an example of singlehop BFD configuration with three seconds timer.

```
interface bgp-sw1-2161-10
    ip address 192.0.1.9 255.111.222.0
    ipv6 address 1111:222::9/112 secondary
    bfd interval 999 min_rx 999 multiplier 3
  #exit
  interface bgp-sw1-2161-11
    ip address 192.0.1.10 255.111.222.0
    ipv6 address 1111:222::10/112 secondary
    bfd interval 999 min_rx 999 multiplier 3
  #exit
  interface bgp-sw1-2161-12
    ip address 192.0.1.11 255.111.222.0
    ipv6 address 1111:222::11/112 secondary
    bfd interval 999 min_rx 999 multiplier 3
  #exit
  interface bgp-sw1-2161-3
    ip address 192.0.1.2 255.111.222.0
    ipv6 address 1111:222::2/112 secondary
    bfd interval 999 min_rx 999 multiplier 3
  #exit
  interface bgp-sw1-2161-4
    ip address 192.0.1.3 255.111.222.0
```

```
             ipv6 address 1111:222::3/112 secondary
             bfd interval 999 min_rx 999 multiplier 3
         #exit
         interface bgp-sw1-2161-5
           ip address 192.0.1.4 255.111.222.0
           ipv6 address 1111:222::4/112 secondary
           bfd interval 999 min_rx 999 multiplier 3
         #exit
         interface bgp-sw1-2161-6
           ip address 192.0.1.5 255.111.222.0
           ipv6 address 1111:222::5/112 secondary
           bfd interval 999 min_rx 999 multiplier 3
         #exit
         interface bgp-sw1-2161-7
           ip address 192.0.1.6 255.111.222.0
           ipv6 address 1111:222::6/112 secondary
           bfd interval 999 min_rx 999 multiplier 3
         #exit
         interface bgp-sw1-2161-8
           ip address 192.0.1.7 255.111.222.0
           ipv6 address 1111:222::7/112 secondary
           bfd interval 999 min_rx 999 multiplier 3
         #exit
         interface bgp-sw1-2161-9
           ip address 192.0.1.8 255.111.222.0
           ipv6 address 1111:222::8/112 secondary
           bfd interval 999 min_rx 999 multiplier 3
         #exit
```

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Static Route for Multihop BFD Configuration

The following is an example of static route multihop BFD configuration.

```
ip route static multihop bfd UP-5 192.111.1.10 192.111.11.10
    ip route static multihop bfd UP-6 192.111.1.10 192.111.12.10
    ip route static multihop bfd UP-9 192.111.1.10 192.111.10.10
    ip route static multihop bfd UP-10 192.111.1.10 192.111.16.10
    ip route static multihop bfd UP-7 192.111.1.10 192.111.13.10
    ip route static multihop bfd UP-8 192.111.1.10 192.111.14.10
```

Static Route for Singlehop BFD Configuration

The following is an example of static route singlehop BFD configuration.

```
ip route static bfd bgp-sw1-2161-3 192.0.1.1
    ip route static bfd bgp-sw1-2161-4 192.0.1.1
    ip route static bfd bgp-sw1-2161-5 192.0.1.1
    ip route static bfd bgp-sw1-2161-6 192.0.1.1
    ip route static bfd bgp-sw1-2161-7 192.0.1.1
    ip route static bfd bgp-sw1-2161-8 192.0.1.1
    ip route static bfd bgp-sw1-2161-9 192.0.1.1
    ip route static bfd bgp-sw1-2161-10 192.0.1.1
    ip route static bfd bgp-sw1-2161-11 192.0.1.1
    ip route static bfd bgp-sw1-2161-12 192.0.1.1
```

IPSec ACL Configuration

The following is an example IPSec ACL configuration in CP.

```
ip access-list UP-1
    permit udp host 192.0.1.1 host 192.0.1.2
    #exit
```

IPSec Transform Set Configuration

The following is an example of IPSec Transform Set configuration in CP.

```
ikev2-ikesa transform-set ikesa-UP-1
    encryption aes-cbc-256
    group 14
    hmac sha2-256-128
    lifetime 28800
    prf sha2-256

  ipsec transform-set A-UP-1
    encryption aes-cbc-256
    hmac sha2-256-128
    group 14
```

IPSec Crypto Map Configuration

The following is an example of IPSec Crypto Map configuration in CP.

```
crypto map UP-1 ikev2-ipv4
    match address UP-1
    authentication local pre-shared-key encrypted key secretkey
    authentication remote pre-shared-key encrypted key secretkey
    ikev2-ikesa max-retransmission 3
    ikev2-ikesa retransmission-timeout 1000
    ikev2-ikesa transform-set list ikesa-UP-1
    ikev2-ikesa rekey
    keepalive interval 4 timeout 1 num-retry 4
    control-dont-fragment clear-bit
    payload foo-sa0 match ipv4
      ipsec transform-set list A-UP-1
      lifetime 300
      rekey keepalive
    #exit
    peer 192.1.1.1
    ikev2-ikesa policy error-notification
  #exit
```

Sx Configuration

The following is an example of Sx configuration in CP.

```
sx-service SX-1
    instance-type controlplane
    sxa max-retransmissions 4
    sxa retransmission-timeout-ms 5000
    sxb max-retransmissions 4
    sxb retransmission-timeout-ms 5000
    sxab max-retransmissions 4
    sxab retransmission-timeout-ms 5000
    n4 max-retransmissions 4
    n4 retransmission-timeout-ms 5000
    sx-protocol heartbeat interval 10
    sx-protocol heartbeat retransmission-timeout 5
    sx-protocol heartbeat max-retransmissions 4
    sx-protocol compression
    sx-protocol supported-features load-control
    sx-protocol supported-features overload-control
  exit
end
```

Example Router Configurations

Static Routes for Interface

The following is an example configuration of static route for interface.

```
ip route 192.1.1.1/32 Vlan1111 192.1.1.2
ip route 192.1.1.1/32 Vlan1111 192.1.1.3
ip route 192.1.1.1/32 Vlan1111 192.1.1.4
ip route 192.1.1.1/32 Vlan1111 192.1.1.5
ip route 192.1.1.1/32 Vlan1111 192.1.1.6
ip route 192.1.1.1/32 Vlan1111 192.1.1.7
ip route 192.1.1.1/32 Vlan1111 192.1.1.8
ip route 192.1.1.1/32 Vlan1111 192.1.1.9
ip route 192.1.1.1/32 Vlan1111 192.1.1.10
ip route 192.1.1.1/32 Vlan1111 192.1.1.11
```

Static Routes for Singlehop BFD

The following is an example configuration of static route for singlehop BFD.

```
ip route static bfd Vlan1111 192.1.1.2
ip route static bfd Vlan1111 192.1.1.3
ip route static bfd Vlan1111 192.1.1.4
ip route static bfd Vlan1111 192.1.1.5
ip route static bfd Vlan1111 192.1.1.6
ip route static bfd Vlan1111 192.1.1.7
ip route static bfd Vlan1111 192.1.1.8
ip route static bfd Vlan1111 192.1.1.9
ip route static bfd Vlan1111 192.1.1.10
ip route static bfd Vlan1111 192.1.1.11
```

Interface for Singlehop BFD

The following is an example configuration of interface for singlehop BFD.

```
interface Vlan1111
  no shutdown
  bandwidth 10000000
  bfd interval 999 min_rx 999 multiplier 3
  no bfd echo
  ip address 192.1.1.1/24
  ipv6 address 1111:222::1/112
```

BGP Configuration

The following is an example of BGP configuration with recommended timers.

```
router bgp 1000
  router-id 192.1.1.1
  timers bgp 30 90
  timers bestpath-limit 300
  timers prefix-peer-timeout 30
  timers prefix-peer-wait 90
  graceful-restart
  graceful-restart restart-time 120
  graceful-restart stalepath-time 300
```

Example Configurations in UP

IPSec ACL Configuration

The following is an example of IPSec ACL configuration in UP.

```
ip access-list CP-1
    permit udp host 192.0.1.1 host 192.0.1.2
   #exit
```

IPSec Transform Set Configuration

The following is an example of IPSec Transform Set configuration in UP.

```
ipsec transform-set A-CP-1
    encryption aes-cbc-256
    hmac sha2-256-128
    group 14

  ikev2-ikesa transform-set ikesa-CP-1
    encryption aes-cbc-256
    group 14
    hmac sha2-256-128
    lifetime 28800
    prf sha2-256
```

IPSec Crypto Map Configuration

The following is an example of IPSec Crypto Map configuration in UP.

```
crypto map CP-1 ikev2-ipv4
    match address CP-1
    authentication local pre-shared-key encrypted key secretkey
    authentication remote pre-shared-key encrypted key secretkey
    ikev2-ikesa max-retransmission 3
    ikev2-ikesa retransmission-timeout 1000
    ikev2-ikesa transform-set list ikesa-CP-1
    ikev2-ikesa rekey
    keepalive interval 5 timeout 2 num-retry 4
    control-dont-fragment clear-bit
    payload foo-sa0 match ipv4
      ipsec transform-set list A-CP-1
    #exit
    peer 192.1.1.2
    ikev2-ikesa policy error-notification
   #exit
```

Sx Configuration

The following is an example of Sx configuration in UP.

```
sx-service SX-1
    instance-type userplane
    sxa max-retransmissions 4
    sxa retransmission-timeout-ms 5000
    sxb max-retransmissions 4
    sxb retransmission-timeout-ms 5000
    sxab max-retransmissions 4
    sxab retransmission-timeout-ms 5000
    n4 max-retransmissions 4
    n4 retransmission-timeout-ms 5000
    sx-protocol heartbeat interval 10
    sx-protocol heartbeat retransmission-timeout 5
    sx-protocol heartbeat max-retransmissions 4
```

```
        sx-protocol compression
      exit
```

Example SRP Configurations

IPSec ACL Configuration

The following is an example of IPSec ACL configuration for SRP.

```
ip access-list SRP
    permit tcp host 192.1.1.1 host 192.1.1.2
  #exit
```

SRP Configuration

The following is an example of SRP configuration.

```
configure
  context srp
    bfd-protocol
      bfd multihop-peer 192.1.1.1 interval 999 min_rx 999 multiplier 3
    #exit
configure
  context srp
    service-redundancy-protocol
      chassis-mode primary
      hello-interval 3
      dead-interval 15
      monitor bfd context srp 192.1.1.6 chassis-to-chassis
      monitor bgp context gi-pgw 192.1.1.7
      monitor bgp context gi-pgw 3333:888::1
      monitor bgp context saegw 192.1.1.7
      monitor bgp context saegw 3333:888::2
      peer-ip-address 192.1.1.6
      bind address 192.0.1.6
    #exit
    ip route static multihop bfd srp 192.0.1.7 192.1.1.7
    ip route 192.2.2.2 255.0.0.1 192.2.2.3 SRP-Physical-2102
    ip route 192.2.2.4 255.0.0.2 192.2.2.5 SRP-Physical-2102
    ip route 192.2.2.6 255.0.0.3 192.2.2.7 SRP-Physical-2102
    ip igmp profile default
    #exit
  #exit
end
```

Sample Configurations

In following sample configuration, the Sx and IPSec interface IP Addresses are defined as:

```
CP Sx - 20.0.0.101
UP Sx - 20.0.0.106
CP IPSec - 192.168.4.1
UP IPSec - 192.168.4.2
```

Note

• For this release, following are the recommended timer values on UP:

```
sx-protocol heartbeat retransmission-timeout 20
sx-protocol heartbeat max-retransmissions 3
```

• For this release, following are the recommended timer values on CP:

```
sx-protocol heartbeat retransmission-timeout 20
sx-protocol heartbeat max-retransmissions 5
```

On Control Plane

IPSec Configuration

```
config
  context EPC-CP
    ip access-list foo0
      permit ip host 20.0.0.101 host 20.0.0.106
    #exit
    ipsec transform-set A-foo
    #exit
    ikev2-ikesa transform-set ikesa-foo
    #exit
    crypto map foo0 ikev2-ipv4
      match address foo0
      authentication local pre-shared-key key secret
      authentication remote pre-shared-key key secret
      ikev2-ikesa max-retransmission 3
      ikev2-ikesa retransmission-timeout 15000
      ikev2-ikesa notify-msg-error no-apn-subscription backoff-timer 0
      ikev2-ikesa notify-msg-error network-failure backoff-timer 0
      ikev2-ikesa transform-set list ikesa-foo
      ikev2-ikesa configuration-attribute p-cscf-v6 private length 0
      ikev2-ikesa configuration-attribute p-cscf-v6 iana length 0
      keepalive interval 50
      payload foo-sa0 match ipv4
        ipsec transform-set list A-foo
        lifetime 300
        rekey keepalive
      #exit
      peer 192.168.4.2
      ikev2-ikesa policy error-notification
      notify-payload error-message-type ue base 0
      notify-payload error-message-type network-transient-minor base 0
      notify-payload error-message-type network-transient-major base 0
      notify-payload error-message-type network-permanent base 0
    #exit
    interface CP_IPSEC loopback
      ip address 192.168.4.1 255.255.255.255
    crypto-map foo0
    #exit
end
```

Sx Configuration

```
    sx-service SX-1
      instance-type controlplane
      bind ipv4-address 20.0.0.101
      sx-protocol heartbeat retransmission-timeout 20
      sx-protocol heartbeat max-retransmissions 5
    exit
```

On User Plane

IPSec Configuration

```
config
  context EPC-UP
    ip access-list foo0
      permit ip host 20.0.0.106 host 20.0.0.101
    #exit
    ipsec transform-set A-foo
    #exit
    ikev2-ikesa transform-set ikesa-foo
    #exit
    crypto map foo0 ikev2-ipv4
      match address foo0
      authentication local pre-shared-key key secret
      authentication remote pre-shared-key key secret
      ikev2-ikesa max-retransmission 3
      ikev2-ikesa retransmission-timeout 15000
      ikev2-ikesa notify-msg-error no-apn-subscription backoff-timer 0
      ikev2-ikesa notify-msg-error network-failure backoff-timer 0
      ikev2-ikesa transform-set list ikesa-foo
      ikev2-ikesa configuration-attribute p-cscf-v6 private length 0
      ikev2-ikesa configuration-attribute p-cscf-v6 iana length 0
      keepalive interval 50
      payload foo-sa0 match ipv4
        ipsec transform-set list A-foo
      #exit
      peer 192.168.4.1
      ikev2-ikesa policy error-notification
      notify-payload error-message-type ue base 0
      notify-payload error-message-type network-transient-minor base 0
      notify-payload error-message-type network-transient-major base 0
      notify-payload error-message-type network-permanent base 0
    #exit
    interface UP_IPSEC  loopback
      ip address 192.168.4.2 255.255.255.255
    crypto-map foo0
    #exit
end
```

Sx Configuration

```
  sx-service SX-1
    instance-type userplane
    bind ipv4-address 20.0.0.106 ipv6-address dddd:51:31:1:209::
    sxa max-retransmissions 12
    sxb max-retransmissions 12
    sxab max-retransmissions 12
    sx-protocol heartbeat interval 30
    sx-protocol heartbeat retransmission-timeout 20
    sx-protocol heartbeat max-retransmissions 3
  exit
```

Monitoring and Troubleshooting

This section contains sample CLI command output of show commands available for the Sx over IPSec feature in both CP and UP.

show crypto ikev2-ikesa security-associations summary

```
I - Initiator
  R - Responder
Mgr                                                              Lifetime
ID  VPN Local IPSec GW:Port   Remote IPSec GW:Port  State        /Remaining
=== === ==================== ===================== ================ ===========
54  2   192.168.170.55 :500   192.168.196.55 :500   AUTH_COMPLETE(I) 86400/16448

1 IKEv2 Security Association found in this context.
```

show crypto ipsec security-associations summary

```
+------ SA state:          (E) - Established
       |                          (P) - Partially Established
       |                          (N) - No SAs
       |
       |+----- Rekey/Keepalive:   (D) - Rekey Disabled
       ||                         (E) - Rekey Enabled/No Keepalive
       ||                         (K) - Rekey Enabled/Keepalive
       ||
       ||+---- Crypto Type:       (D) - Dynamic Map
       |||                        (I) - IKEv1 Map
       |||                        (J) - IKEv2 Map
       |||                        (M) - Manual Map
       |||                        (C) - CSCF Map
       |||
       |||
       VVV           Map Name                                    Rekeys En Pkts
    De Pkts
===== === ====================================================== ====== ==========
 ==========
1     EDJ foo0                                                    0      3496
      3496

1 Crypto Map Found.
1 Crypto Map Established.
```