

IP Security

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General Information

Specifications

Packages required: *security*

License required: *level1*

Home menu level: */ip ipsec*

Standards and Technologies: *IPsec*

Hardware usage: *consumes a lot of CPU time (Intel Pentium MMX or AMD K6 suggested as a minimal configuration)*

Description

IPsec (IP Security) supports secure (encrypted, digitally signed) communications over IP networks.

Encryption

After packet is src-natted (if needed), but before putting it into interface queue, IPsec policy database is consulted to find out if packet should be encrypted. Security Policy Database (SPD) is a list of rules that have two parts:

- **Packet matching** - packet source/destination, protocol and ports (for TCP and UDP) are compared to values in policy rules, one after another
- **Action** - if rule matches action specified in rule is performed:
 - **none** - continue with the packet as if there was no IPsec
 - **discard** - drop the packet
 - **encrypt** - apply IPsec transformations to the packet

Each SPD rule can be associated with several Security Associations (SA) that determine packet encryption parameters (key, algorithm, SPI).

Note that packet can only be encrypted if there is a usable SA for policy rule. Same SA may be used for different policies, unless especially prohibited by a policy. By setting SPD rule security "level" user can control what happens when there is no valid SA for policy rule:

- **use** - if there is no valid SA, send packet unencrypted (like accept rule)
- **require** - drop packet, and ask IKE daemon to establish a new SA.
- **unique** - same as require, but establish a unique SA for this policy (i.e., this SA may not be shared with other policy)

Decryption

When encrypted packet is received for local host (after **dst-nat** and **input** filter), the appropriate SA is looked up to decrypt it (using packet source, destination, security protocol and SPI value). If no SA is found, the packet is dropped. If SA is found, packet is decrypted. Then decrypted packet's fields are compared to the policy rule that SA is linked to. If the packet does not match the policy rule, it is dropped. If the packet is decrypted fine (or authenticated fine) it is "received once more" - it goes through **dst-nat** and routing (which finds out what to do - either forward or deliver locally) again.

Note that before **forward** and **input** firewall chains, a packet that was not decrypted on local host is compared with SPD reversing its matching rules. If SPD requires encryption (there is valid SA associated with matching SPD rule), the packet is dropped. This is called incoming policy check.

Internet Key Exchange

The Internet Key Exchange (IKE) is a protocol that provides authenticated keying material for Internet Security Association and Key Management Protocol (ISAKMP) framework. There are other key exchange schemes that work with ISAKMP, but IKE is the most widely used one. Together they provide means for

authentication of hosts and automatic management of security associations (SA).

Most of the time IKE daemon is doing nothing. There are two possible situations when it is activated:

- There is some traffic caught by a policy rule which needs to become encrypted or authenticated, but the policy doesn't have any SAs. The policy notifies IKE daemon about that, and IKE daemon initiates connection to remote host.
- IKE daemon responds to remote connection.

In both cases, peers establish connection and execute 2 phases:

- **Phase 1** - The peers agree upon algorithms they will use in the following IKE messages and authenticate. The keying material used to derive keys for all SAs and to protect following ISAKMP exchanges between hosts is generated also.
- **Phase 2** - The peers establish one or more SAs that will be used by IPsec to encrypt data. All SAs established by IKE daemon will have lifetime values (either limiting time, after which SA will become invalid, or amount of data that can be encrypted by this SA, or both).

There are two lifetime values - soft and hard. When SA reaches it's soft lifetime treshold, the IKE daemon receives a notice and starts another phase 2 exchange to replace this SA with fresh one. If SA reaches hard lifetime, it is discarded.

IKE can optionally provide a Perfect Forward Secrecy (PFS), which is a property of key exchanges, that, in turn, means for IKE that compromising the long term phase 1 key will not allow to easily gain access to all IPsec data that is protected by SAs established through this phase 1. It means an additional keying material is generated for each phase 2.

Generation of keying material is computationally very expensive. *Exempli gratia*, the use of modp8192 group can take several seconds even on very fast computer. It usually takes place once per phase 1 exchange, which happens only once between any host pair and then is kept for long time. PFS adds this expensive operation also to each phase 2 exchange.

Diffie-Hellman Groups

Diffie-Hellman (DH) key exchange protocol allows two parties without any initial shared secret to create one securely. The following Modular Exponential (MODP) and Elliptic Curve (EC2N) Diffie-Hellman (also known as "Oakley") Groups are supported:

Diffie-Hellman Group	Name	Reference
Group 1	768 bit MODP group	RFC2409
Group 2	1024 bits MODP group	RFC2409
Group 3	EC2N group on GP(2 ¹⁵⁵)	RFC2409
Group 4	EC2N group on GP(2 ¹⁸⁵)	RFC2409
Group 5	1536 bits MODP group	RFC3526

IKE Traffic

To avoid problems with IKE packets hit some SPD rule and require to encrypt it with not yet established SA

(that this packet perhaps is trying to establish), locally originated packets with UDP source port 500 are not processed with SPD. The same way packets with UDP destination port 500 that are to be delivered locally are not processed in incoming policy check.

Setup Procedure

To get IPsec to work with automatic keying using IKE-ISAKMP you will have to configure **policy**, **peer** and **proposal** (optional) entries.

For manual keying you will have to configure **policy** and **manual-sa** entries.

Policy Settings

Home menu level: */ip ipsec policy*

Description

Policy table is needed to determine whether security settings should be applied to a packet.

Property Description

action (*none | discard | encrypt*; default: **accept**) - specifies what action to undertake with a packet that matches the policy

- **none** - pass the packet unchanged
- **discard** - drop the packet
- **encrypt** - apply transformations specified in this policy and it's SA

dont-fragment (*clear | inherit | set*; default: **clear**) - The state of the don't fragment IP header field

- **clear** - clear (unset) the field, so that packets previously marked as don't fragment can be fragmented. This setting is recommended as the packets are getting larger when IPsec protocol is applied to them, so large packets with don't fragment flag will not be able to pass the router
- **inherit** - do not change the field
- **set** - set the field, so that each packet matching the rule will not be fragmented. Not recommended

dst-address (*IP addressnetmaskport*; default: **0.0.0.0/32:any**) - destination IP address

dynamic (*read-only: flag*) - whether the rule has been created dynamically

in-accepted (*integer*) - how many incoming packets were passed through by the policy without an attempt to decrypt

in-dropped (*integer*) - how many incoming packets were dropped by the policy without an attempt to decrypt

in-transformed (*integer*) - how many incoming packets were decrypted (ESP) and/or verified (AH) by the policy

inactive (*read-only: flag*) - whether the rule is inactive (it may become inactive due to some misconfiguration)

ipsec-protocols (*multiple choice: ah | esp*; default: **esp**) - specifies what combination of Authentication Header and Encapsulating Security Payload protocols you want to apply to matched

traffic. AH is applied after ESP, and in case of tunnel mode ESP will be applied in tunnel mode and AH - in transport mode

level (*unique | require | use*; default: **require**) - specifies what to do if some of the SAs for this policy cannot be found:

- **use** - skip this transform, do not drop packet and do not acquire SA from IKE daemon
- **require** - drop packet and acquire SA
- **unique** - drop packet and acquire a unique SA that is only used with this particular policy

manual-sa (*name*; default: **none**) - name of manual-sa template that will be used to create SAs for this policy

- **none** - no manual keys are set

out-accepted (*integer*) - how many outgoing packets were passed through by the policy without an attempt to encrypt

out-dropped (*integer*) - how many outgoing packets were dropped by the policy without an attempt to encrypt

out-transformed (*integer*) - how many outgoing packets were encrypted (ESP) and/or signed (AH)

ph2-state (*read-only: expired | no-phase2 | established*) - indication of the progress of key establishing

- **expired** - there are some leftovers from previous phase2. In general it is similar to no-phase2
- **no-phase2** - no keys are established at the moment
- **established** - Appropriate SAs are in place and everything should be working fine

priority (*integer*; default: **0**) - policy ordering classificator (signed integer). Larger number means higher priority

proposal (*name*; default: **default**) - name of proposal information that will be sent by IKE daemon to establish SAs for this policy

protocol (*nameinteger*; default: **all**) - IP packet protocol to match

sa-dst-address (*IP address*; default: **0.0.0.0**) - SA destination IP address (remote peer)

sa-src-address (*IP address*; default: **0.0.0.0**) - SA source IP address (local peer)

src-address (*IP addressnetmaskport*; default: **0.0.0.0/32:any**) - source IP address

tunnel (yes | no; default: **no**) - specifies whether to use tunnel mode

Notes

All packets are IPsec encapsulated in tunnel mode, and their new IP header's **src-address** and **dst-address** are set to **sa-src-address** and **sa-dst-address** values of this policy. If you do not use tunnel mode (*id est* you use transport mode), then only packets whose source and destination addresses are the same as **sa-src-address** and **sa-dst-address** can be processed by this policy. Transport mode can only work with packets that originate at and are destined for IPsec peers (hosts that established security associations). To encrypt traffic between networks (or a network and a host) you have to use tunnel mode.

It is good to have **dont-fragment** cleared because encrypted packets are always bigger than original and thus they may need fragmentation.

If you are using IKE to establish SAs automatically, then policies on both routers must exactly match each other, *id est* **src-address=1.2.3.0/27** on one router and **dst-address=1.2.3.0/28** on another would

not work. Source address values on one router MUST be equal to destination address values on the other one, and vice versa.

Example

To add a policy to encrypt all the traffic between two hosts (10.0.0.147 and 10.0.0.148), we need do the following:

```
[admin@MikroTik] ip ipsec policy> add sa-src-address=10.0.0.147 \
...\ sa-dst-address=10.0.0.148 action=encrypt
[admin@MikroTik] ip ipsec policy> print
Flags: X - disabled, D - dynamic, I - inactive
0  src-address=10.0.0.147/32:any dst-address=10.0.0.148/32:any protocol=all
   action=encrypt level=require ipsec-protocols=esp tunnel=no
   sa-src-address=10.0.0.147 sa-dst-address=10.0.0.148 proposal=default
   manual-sa=none priority=0

[admin@MikroTik] ip ipsec policy>
```

to view the policy statistics, do the following:

```
[admin@MikroTik] ip ipsec policy> print stats
Flags: X - disabled, D - dynamic, I - inactive
0  src-address=10.0.0.147/32:any dst-address=10.0.0.148/32:any
   protocol=all ph2-state=no-phase2 in-accepted=0 in-dropped=0
   out-accepted=0 out-dropped=0 encrypted=0 not-encrypted=0 decrypted=0
   not-decrypted=0

[admin@MikroTik] ip ipsec policy>
```

Peers

Home menu level: */ip ipsec peer*

Description

Peer configuration settings are used to establish connections between IKE daemons (phase 1 configuration). This connection then will be used to negotiate keys and algorithms for SAs.

Property Description

address (*IP addressnetmaskport*; default: **0.0.0.0/32:500**) - address prefix. If remote peer's address matches this prefix, then this peer configuration is used while authenticating and establishing phase 1. If several peer's addresses matches several configuration entries, the most specific one (i.e. the one with largest netmask) will be used

auth-method (*pre-shared-key | rsa-signature*; default: **pre-shared-key**) - authentication method

- **pre-shared-key** - authenticate by a password (secret) string shared between the peers
- **rsa-signature** - authenticate using a pair of RSA certificates

certificate (*name*) - name of a certificate on the local side (signing packets; the certificate must have private key). Only needed if RSA signature authentication method is used

dh-group (*multiple choice: ec2n155 | ec2n185 | modp768 | modp1024 | modp1536*; default: **modp1024**) - Diffie-Hellman group (cipher strength)

enc-algorithm (*multiple choice: des | 3des | aes-128 | aes-192 | aes-256*; default: **3des**) - encryption algorithm. Algorithms are named in strength increasing order

exchange-mode (*multiple choice: main | aggressive | base*; default: **main**) - different ISAKMP phase 1 exchange modes according to RFC 2408. Do not use other modes than main unless you know what you are doing

generate-policy (yes | no; default: **no**) - allow this peer to establish SA for non-existing policies. Such policies are created dynamically for the lifetime of SA. This way it is possible, for example, to create IPsec secured L2TP tunnels, or any other setup where remote peer's IP address is not known at the configuration time

hash-algorithm (*multiple choice: md5 | sha1*; default: **md5**) - hashing algorithm. SHA (Secure Hash Algorithm) is stronger, but slower

lifebytes (*integer*; default: **0**) - phase 1 lifetime: specifies how much bytes can be transferred before SA is discarded

- **0** - SA expiration will not be due to byte count excess

lifetime (*time*; default: **1d**) - phase 1 lifetime: specifies how long the SA will be valid; SA will be discarded after this time

nat-traversal (yes | no; default: **no**) - use Linux NAT-T mechanism to solve IPsec incompatibility with NAT routers inbetween IPsec peers. This can only be used with ESP protocol (AH is not supported by design, as it signs the complete packet, including IP header, which is changed by NAT, rendering AH signature invalid). The method encapsulates IPsec ESP traffic into UDP streams in order to overcome some minor issues that made ESP incompatible with NAT

proposal-check (*multiple choice: claim | exact | obey | strict*; default: **strict**) - phase 2 lifetime check logic:

- **claim** - take shortest of proposed and configured lifetimes and notify initiator about it
- **exact** - require lifetimes to be the same
- **obey** - accept whatever is sent by an initiator
- **strict** - if proposed lifetime is longer than the default then reject proposal otherwise accept proposed lifetime

remote-certificate (*name*) - name of a certificate for authenticating the remote side (validating packets; no private key required). Only needed if RSA signature authentication method is used

secret (*text*; default: **""**) - secret string (in case pre-shared key authentication is used). If it starts with '0x', it is parsed as a hexadecimal value

send-initial-contact (yes | no; default: **yes**) - specifies whether to send initial IKE information or wait for remote side

Notes

AES (Advanced Encryption Standard) encryption algorithms are much faster than DES, so it is recommended to use this algorithm class whenever possible. But, AES's speed is also its drawback as it potentially can be cracked faster, so use AES-256 when you need security or AES-128 when speed is also important.

Both peers **MUST** have the same encryption and authentication algorithms, DH group and exchange mode. Some legacy hardware may support only DES and MD5.

You should set **generate-policy** flag to **yes** only for trusted peers, because there is no verification done for the established policy. To protect yourself against possible unwanted events, add policies with **action=none** for all networks you don't want to be encrypted at the top of policy list. Since dynamic policies are added at the bottom of the list, they will not be able to override your configuration. Alternatively

you can use policy priorities to enforce some policies to be active always.

Example

To define new peer configuration for **10.0.0.147** peer with **secret=gwejimezyfopmekun**:

```
[admin@MikroTik] ip ipsec peer>add address=10.0.0.147/32 \  
\... secret=gwejimezyfopmekun  
[admin@MikroTik] ip ipsec peer> print  
Flags: X - disabled  
 0 address=10.0.0.147/32:500 auth-method=pre-shared-key  
  secret="gwejimezyfopmekun" generate-policy=no exchange-mode=main  
  send-initial-contact=yes nat-traversal=no proposal-check=obey  
  hash-algorithm=md5 enc-algorithm=3des dh-group=modp1024 lifetime=1d  
  lifebytes=0  
[admin@MikroTik] ip ipsec peer>
```

Remote Peer Statistics

Home menu level: */ip ipsec remote-peers*

Description

This submenu provides you with various statistics about remote peers that currently have established phase 1 connections with this router. Note that if peer doesn't show up here, it doesn't mean that no IPsec traffic is being exchanged with it. For example, manually configured SAs will not show up here.

Property Description

local-address (*read-only: IP address*) - local ISAKMP SA address

remote-address (*read-only: IP address*) - peer's IP address

side (*multiple choice, read-only: initiator | responder*) - shows which side initiated the connection

- **initiator** - phase 1 negotiation was started by this router
- **responder** - phase 1 negotiation was started by peer

state (*read-only: text*) - state of phase 1 negotiation with the peer

- **established** - normal working state

Example

To see currently established SAs:

```
[admin@MikroTik] ip ipsec> remote-peers print  
 0 local-address=10.0.0.148 remote-address=10.0.0.147 state=established  
  side=initiator  
[admin@MikroTik] ip ipsec>
```

Installed SAs

Home menu level: */ip ipsec installed-sa*

Description

This facility provides information about installed security associations including the keys

Property Description

add-lifetime (*read-only: time*) - soft/hard expiration time counted from installation of SA

addtime (*read-only: text*) - time when this SA was installed

auth-algorithm (*multiple choice, read-only: none | md5 | sha1*) - authentication algorithm used in SA

auth-key (*read-only: text*) - authentication key presented as a hex string

current-bytes (*read-only: integer*) - amount of data processed by this SA's crypto algorithms

dst-address (*read-only: IP address*) - destination address of SA taken from respective policy

enc-algorithm (*multiple choice, read-only: none | des | 3des | aes*) - encryption algorithm used in SA

enc-key (*read-only: text*) - encryption key presented as a hex string (not applicable to AH SAs)

lifebytes (*read-only: integer*) - soft/hard expiration threshold for amount of processed data

replay (*read-only: integer*) - size of replay window presented in bytes. This window protects the receiver against replay attacks by rejecting old or duplicate packets

spi (*read-only: integer*) - SPI value of SA, represented in hexadecimal form

src-address (*read-only: IP address*) - source address of SA taken from respective policy

state (*multiple choice, read-only: larval | mature | dying | dead*) - SA living phase

use-lifetime (*read-only: time*) - soft/hard expiration time counted from the first use of SA

usetime (*read-only: text*) - time when this SA was first used

Example

Sample printout looks as follows:

```
[admin@MikroTik] ip ipsec> installed-sa print
Flags: A - AH, E - ESP, P - pfs
 0 E   spi=E727605 src-address=10.0.0.148 dst-address=10.0.0.147
      auth-algorithm=sha1 enc-algorithm=3des replay=4 state=mature
      auth-key="ecc5f4aee1b297739ec88e324d7cfb8594aa6c35"
      enc-key="d6943b8ea582582e449bde085c9471ab0b209783c9eb4bbd"
      addtime=jan/28/2003 20:55:12 add-lifetime=24m/30m
      usetime=jan/28/2003 20:55:23 use-lifetime=0s/0s current-bytes=128
      lifebytes=0/0

 1 E   spi=E15CEE06 src-address=10.0.0.147 dst-address=10.0.0.148
      auth-algorithm=sha1 enc-algorithm=3des replay=4 state=mature
      auth-key="8ac9dc7ecefbed9cd1030ae3b07b32e8e5cb98af"
      enc-key="8a8073a7afd0f74518c10438a0023e64cc660ed69845ca3c"
      addtime=jan/28/2003 20:55:12 add-lifetime=24m/30m
      usetime=jan/28/2003 20:55:12 use-lifetime=0s/0s current-bytes=512
      lifebytes=0/0
[admin@MikroTik] ip ipsec>
```

Flushing Installed SA Table

Command name: */ip ipsec installed-sa flush*

Description

Sometimes after incorrect/incomplete negotiations took place, it is required to flush manually the installed SA table so that SA could be renegotiated. This option is provided by the **flush** command.

Property Description

sa-type (*multiple choice: ah | all | esp*; default: **all**) - specifies SA types to flush

- **ah** - delete AH protocol SAs only
- **esp** - delete ESP protocol SAs only
- **all** - delete both ESP and AH protocols SAs

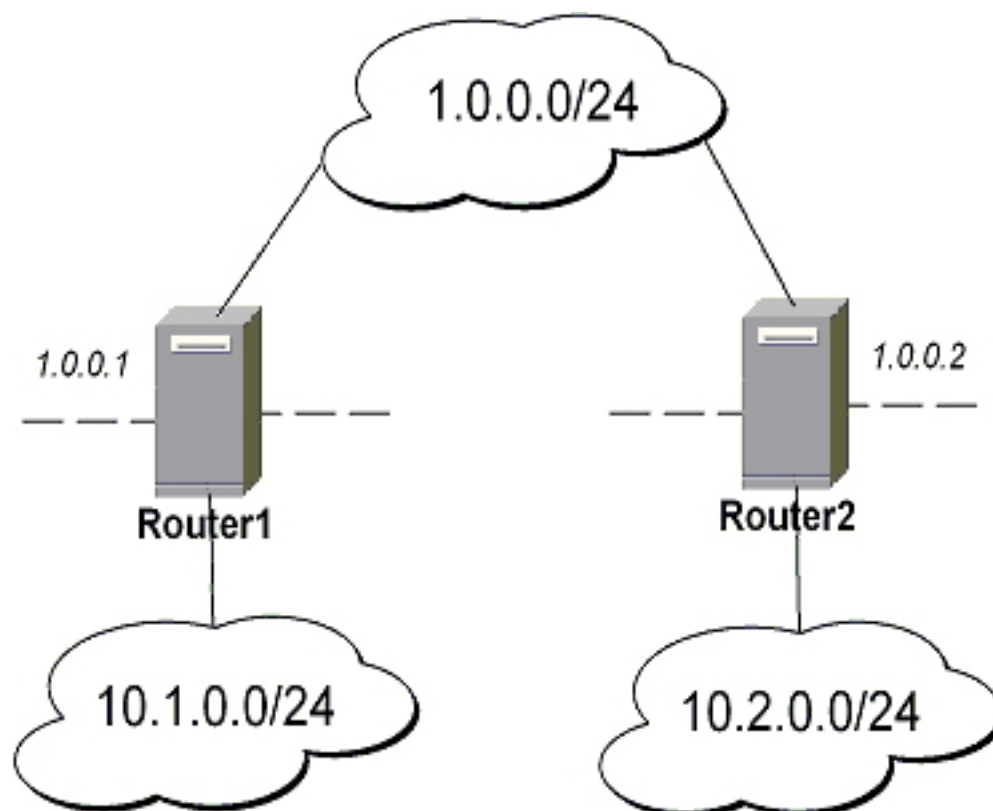
Example

To flush all the SAs installed:

```
[admin@MikroTik] ip ipsec installed-sa> flush
[admin@MikroTik] ip ipsec installed-sa> print
[admin@MikroTik] ip ipsec installed-sa>
```

Application Examples

MikroTik Router to MikroTik Router



- transport mode example using ESP with automatic keying
 - for **Router1**

```
[admin@Router1] > ip ipsec policy add sa-src-address=1.0.0.1 sa-dst-address=1.0.0.2 \  
\... action=encrypt  
[admin@Router1] > ip ipsec peer add address=1.0.0.2 \  
\... secret="gvejimezyfopmekun"
```

- **for Router2**

```
[admin@Router2] > ip ipsec policy add sa-src-address=1.0.0.2 sa-dst-address=1.0.0.1 \  
\... action=encrypt  
[admin@Router2] > ip ipsec peer add address=1.0.0.1 \  
\... secret="gvejimezyfopmekun"
```

- transport mode example using ESP with automatic keying and automatic policy generating on Router 1 and static policy on Router 2

- **for Router1**

```
[admin@Router1] > ip ipsec peer add address=1.0.0.0/24 \  
\... secret="gvejimezyfopmekun" generate-policy=yes
```

- **for Router2**

```
[admin@Router2] > ip ipsec policy add sa-src-address=1.0.0.2 sa-dst-address=1.0.0.1 \  
\... action=encrypt  
[admin@Router2] > ip ipsec peer add address=1.0.0.1 \  
\... secret="gvejimezyfopmekun"
```

- tunnel mode example using AH with manual keying

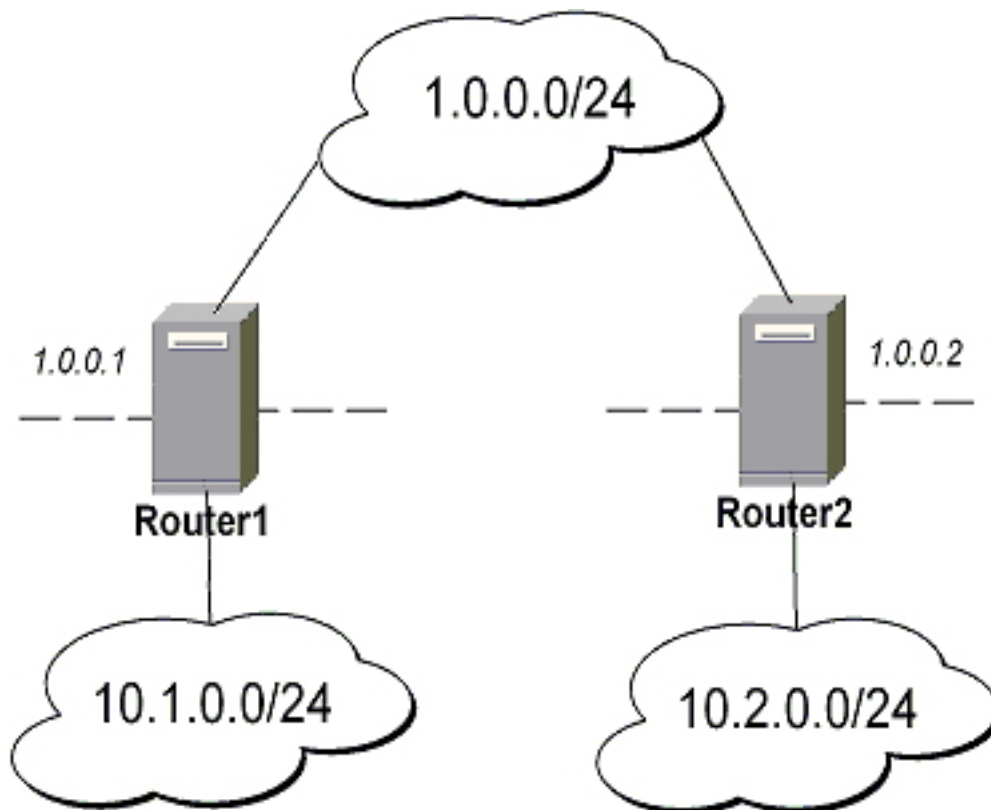
- **for Router1**

```
[admin@Router1] > ip ipsec manual-sa add name=ah-sa1 \  
\... ah-spi=0x101/0x100 ah-key=abcfed  
[admin@Router1] > ip ipsec policy add src-address=10.1.0.0/24 \  
\... dst-address=10.2.0.0/24 action=encrypt ipsec-protocols=ah \  
\... tunnel=yes sa-src=1.0.0.1 sa-dst=1.0.0.2 manual-sa=ah-sa1
```

- **for Router2**

```
[admin@Router2] > ip ipsec manual-sa add name=ah-sa1 \  
\... ah-spi=0x100/0x101 ah-key=abcfed  
[admin@Router2] > ip ipsec policy add src-address=10.2.0.0/24 \  
\... dst-address=10.1.0.0/24 action=encrypt ipsec-protocols=ah \  
\... tunnel=yes sa-src=1.0.0.2 sa-dst=1.0.0.1 manual-sa=ah-sa1
```

IPsec Between two Masquerading MikroTik Routers



1. Add accept and masquerading rules in SRC-NAT

- for **Router1**

```
[admin@Router1] > ip firewall nat add chain=srcnat src-address=10.1.0.0/24 \
\... dst-address=10.2.0.0/24 action=accept
[admin@Router1] > ip firewall nat add chain=srcnat out-interface=public \
\... action=masquerade
```

- for **Router2**

```
[admin@Router2] > ip firewall nat chain=srcnat add src-address=10.2.0.0/24 \
\... dst-address=10.1.0.0/24 action=accept
[admin@Router2] > ip firewall nat chain=srcnat add out-interface=public \
\... action=masquerade
```

2. configure IPsec

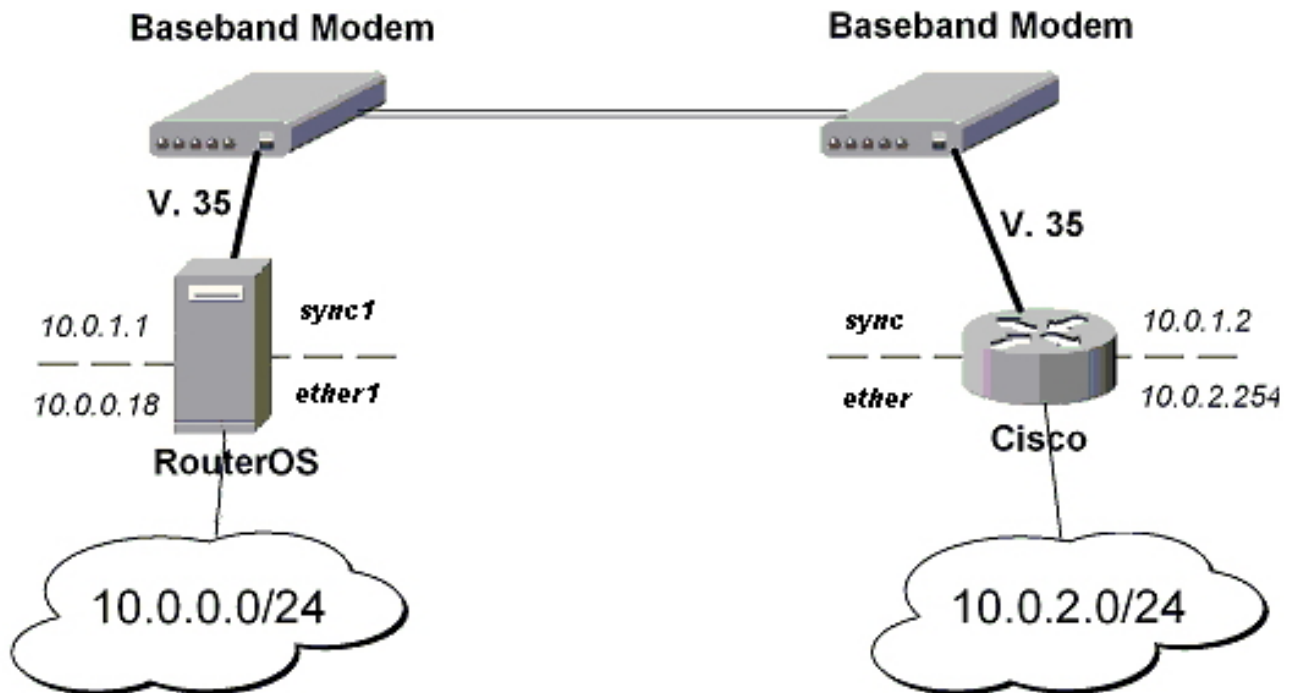
- for **Router1**

```
[admin@Router1] > ip ipsec policy add src-address=10.1.0.0/24 \
\... dst-address=10.2.0.0/24 action=encrypt tunnel=yes \
\... sa-src-address=1.0.0.1 sa-dst-address=1.0.0.2
[admin@Router1] > ip ipsec peer add address=1.0.0.2 \
\... exchange-mode=aggressive secret="gvejimezyfopmekun"
```

- for **Router2**

```
[admin@Router2] > ip ipsec policy add src-address=10.2.0.0/24 \
\... dst-address=10.1.0.0/24 action=encrypt tunnel=yes \
\... sa-src-address=1.0.0.2 sa-dst-address=1.0.0.1
[admin@Router2] > ip ipsec peer add address=1.0.0.1 \
\... exchange-mode=aggressive secret="gvejimezyfopmekun"
```

MikroTik router to CISCO Router



We will configure IPsec in tunnel mode in order to protect traffic between attached subnets.

1. Add peer (with phase1 configuration parameters), DES and SHA1 will be used to protect IKE traffic
 - for **MikroTik** router

```
[admin@MikroTik] > ip ipsec peer add address=10.0.1.2 \
\... secret="gvejimezyfopmekun" enc-algorithm=des
```

- for **CISCO** router

```
! Configure ISAKMP policy (phase1 config, must match configuration
! of "/ip ipsec peer" on RouterOS). Note that DES is default
! encryption algorithm on Cisco. SHA1 is default authentication
! algorithm
crypto isakmp policy 9
  encryption des
  authentication pre-share
  group 2
  hash md5
  exit

! Add preshared key to be used when talking to RouterOS
crypto isakmp key gvejimezyfopmekun address 10.0.1.1 255.255.255.255
```

2. Set encryption proposal (phase2 proposal - settings that will be used to encrypt actual data) to use DES to encrypt data
 - for **MikroTik** router

```
[admin@MikroTik] > ip ipsec proposal set default enc-algorithms=des
```

- for **CISCO** router

```

! Create IPsec transform set - transformations that should be applied to
! traffic - ESP encryption with DES and ESP authentication with SHA1
! This must match "/ip ipsec proposal"
crypto ipsec transform-set myset esp-des esp-sha-hmac
mode tunnel
exit

```

3. Add policy rule that matches traffic between subnets and requires encryption with ESP in tunnel mode

- for **MikroTik** router

```

[admin@MikroTik] > ip ipsec policy add \
\... src-address=10.0.0.0/24 dst-address=10.0.2.0/24 action=encrypt \
\... tunnel=yes sa-src=10.0.1.1 sa-dst=10.0.1.2

```

- for **CISCO** router

```

! Create access list that matches traffic that should be encrypted
access-list 101 permit ip 10.0.2.0 0.0.0.255 10.0.0.0 0.0.0.255
! Create crypto map that will use transform set "myset", use peer 10.0.1.1
! to establish SAs and encapsulate traffic and use access-list 101 to
! match traffic that should be encrypted
crypto map mymap 10 ipsec-isakmp
set peer 10.0.1.1
set transform-set myset
set pfs group2
match address 101
exit
! And finally apply crypto map to serial interface:
interface Serial 0
crypto map mymap
exit

```

4. Testing the IPsec tunnel

- on **MikroTik** router we can see installed SAs

```

[admin@MikroTik] ip ipsec installed-sa> print
Flags: A - AH, E - ESP, P - pfs
 0 E spi=9437482 src-address=10.0.1.1 dst-address=10.0.1.2
auth-algorithm=sha1 enc-algorithm=des replay=4 state=mature
auth-key="9cf2123b8b5add950e3e67b9eac79421d406aa09"
enc-key="ffe7ec65b7a385c3" addtime=jul/12/2002 16:13:21
add-lifetime=24m/30m usetime=jul/12/2002 16:13:21 use-lifetime=0s/0s
current-bytes=71896 lifebytes=0/0
 1 E spi=319317260 src-address=10.0.1.2 dst-address=10.0.1.1
auth-algorithm=sha1 enc-algorithm=des replay=4 state=mature
auth-key="7575f5624914dd312839694db2622a318030bc3b"
enc-key="633593f809c9d6af" addtime=jul/12/2002 16:13:21
add-lifetime=24m/30m usetime=jul/12/2002 16:13:21 use-lifetime=0s/0s
current-bytes=0 lifebytes=0/0
[admin@MikroTik] ip ipsec installed-sa>

```

- on **CISCO** router

```

cisco# show interface Serial 0
interface: Serial1
Crypto map tag: mymap, local addr. 10.0.1.2
local ident (addr/mask/prot/port): (10.0.2.0/255.255.255.0/0/0)
remote ident (addr/mask/prot/port): (10.0.0.0/255.255.255.0/0/0)
current_peer: 10.0.1.1
PERMIT, flags={origin_is_acl,}
#pkts encaps: 1810, #pkts encrypt: 1810, #pkts digest 1810
#pkts decaps: 1861, #pkts decrypt: 1861, #pkts verify 1861
#pkts compressed: 0, #pkts decompressed: 0
#pkts not compressed: 0, #pkts compr. failed: 0, #pkts decompress failed: 0
#send errors 0, #recv errors 0
local crypto endpt.: 10.0.1.2, remote crypto endpt.: 10.0.1.1
path mtu 1500, media mtu 1500

```

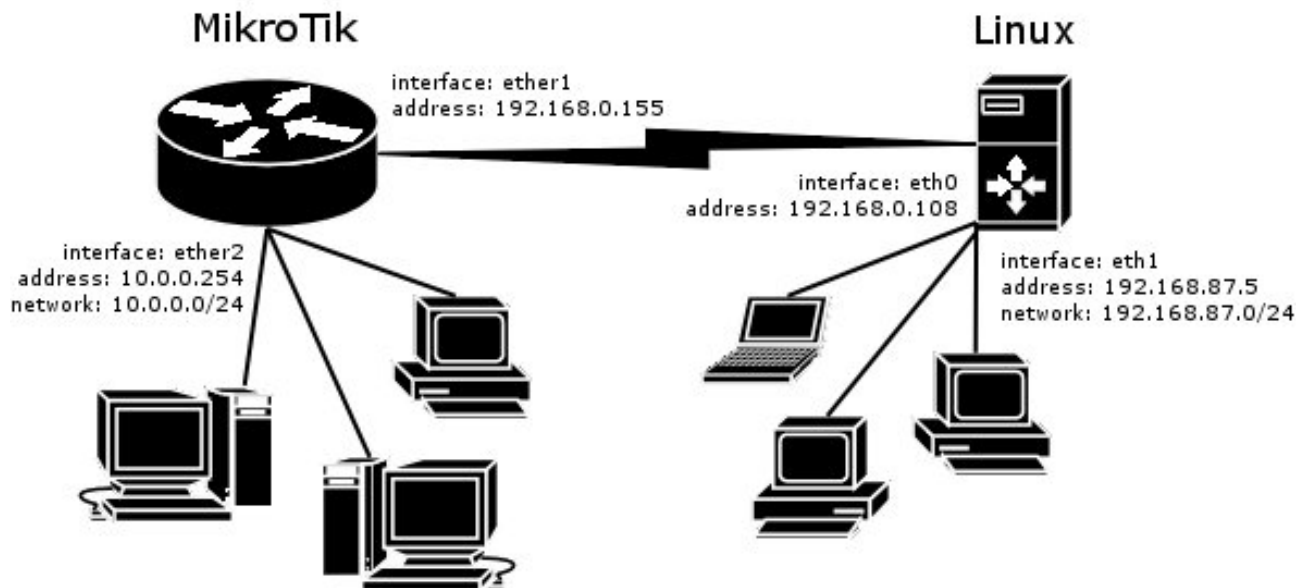
```

current outbound spi: 1308650C
inbound esp sas:
  spi: 0x90012A(9437482)
    transform: esp-des esp-sha-hmac ,
    in use settings ={Tunnel, }
    slot: 0, conn id: 2000, flow_id: 1, crypto map: mymap
    sa timing: remaining key lifetime (k/sec): (4607891/1034)
    IV size: 8 bytes
    replay detection support: Y
inbound ah sas:
inbound pcp sas:
outbound esp sas:
  spi: 0x1308650C(319317260)
    transform: esp-des esp-sha-hmac ,
    in use settings ={Tunnel, }
    slot: 0, conn id: 2001, flow_id: 2, crypto map: mymap
    sa timing: remaining key lifetime (k/sec): (4607893/1034)
    IV size: 8 bytes
    replay detection support: Y
outbound ah sas:
outbound pcp sas:

```

MikroTik Router and Linux FreeS/WAN

In the test scenario we have 2 private networks: 10.0.0.0/24 connected to the MT and 192.168.87.0/24 connected to Linux. MT and Linux are connected together over the "public" network 192.168.0.0/24:



- FreeS/WAN configuration:

```

config setup
  interfaces="ipsec0=eth0"
  klipsdebug=none
  plutodebug=all
  plutoload=%search
  plutostart=%search
  uniqueids=yes

conn %default
  keyingtries=0
  disablearrivalcheck=no
  authby=rsasig

conn mt

```

```
left=192.168.0.108
leftsubnet=192.168.87.0/24
right=192.168.0.155
rightsubnet=10.0.0.0/24
authby=secret
pfs=no
auto=add
```

- **ipsec.secrets** config file:

```
192.168.0.108 192.168.0.155 : PSK "gvejimezyfopmekun"
```

- MikroTik Router configuration:

```
[admin@MikroTik] > /ip ipsec peer add address=192.168.0.108 \  
\... secret="gvejimezyfopmekun" hash-algorithm=md5 enc-algorithm=3des \  
\... dh-group=modp1024 lifetime=28800s  
  
[admin@MikroTik] > /ip ipsec proposal auth-algorithms=md5 \  
\... enc-algorithms=3des pfs-group=none  
  
[admin@MikroTik] > /ip ipsec policy add sa-src-address=192.168.0.155 \  
\... sa-dst-address=192.168.0.108 src-address=10.0.0.0/24 \  
\... dst-address=192.168.87.0/24 tunnel=yes
```