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IKEv2-based VPNs using strongSwan

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Where the heck is Rapperswil?

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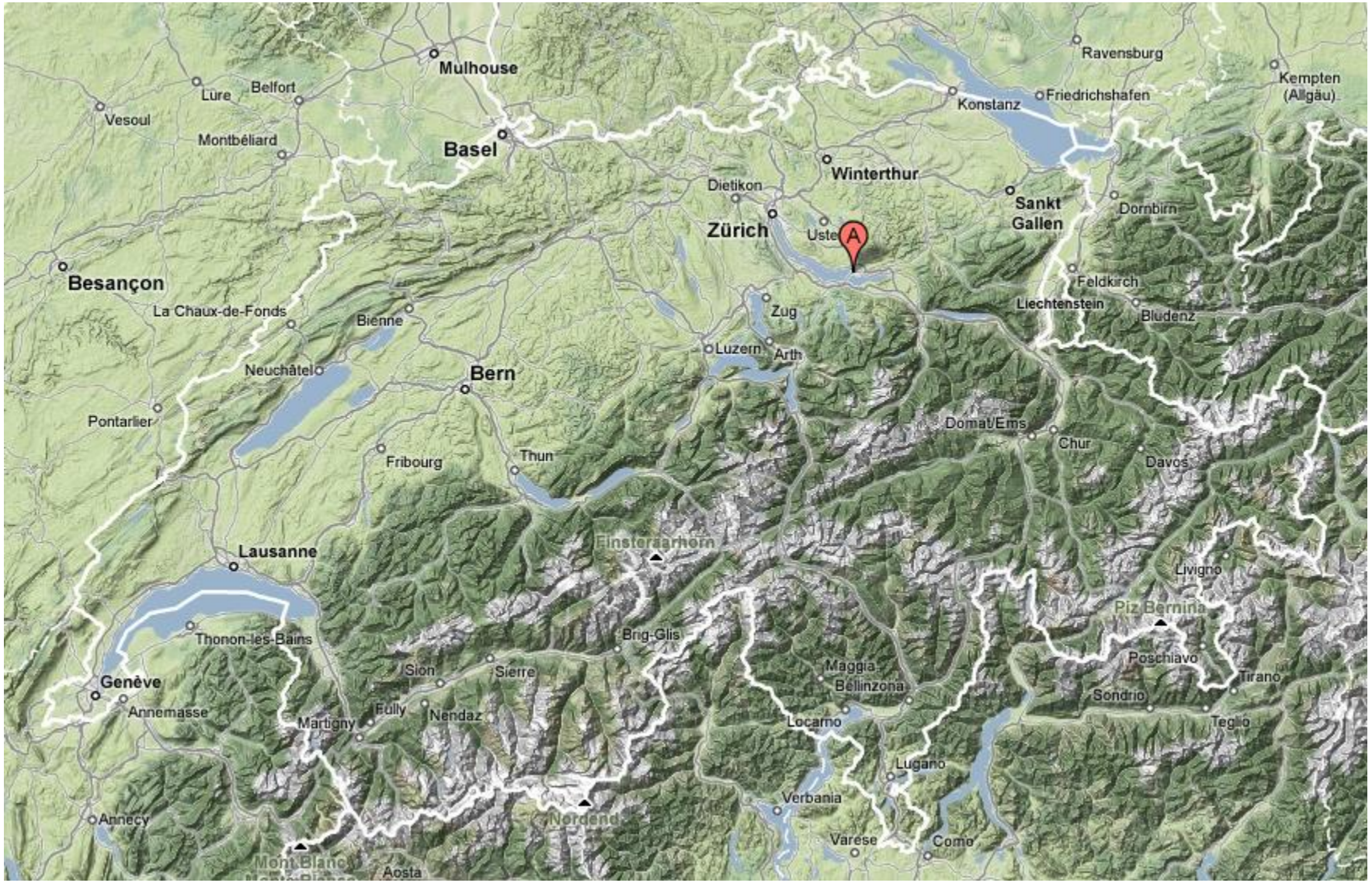

HSR - Hochschule für Technik Rapperswil

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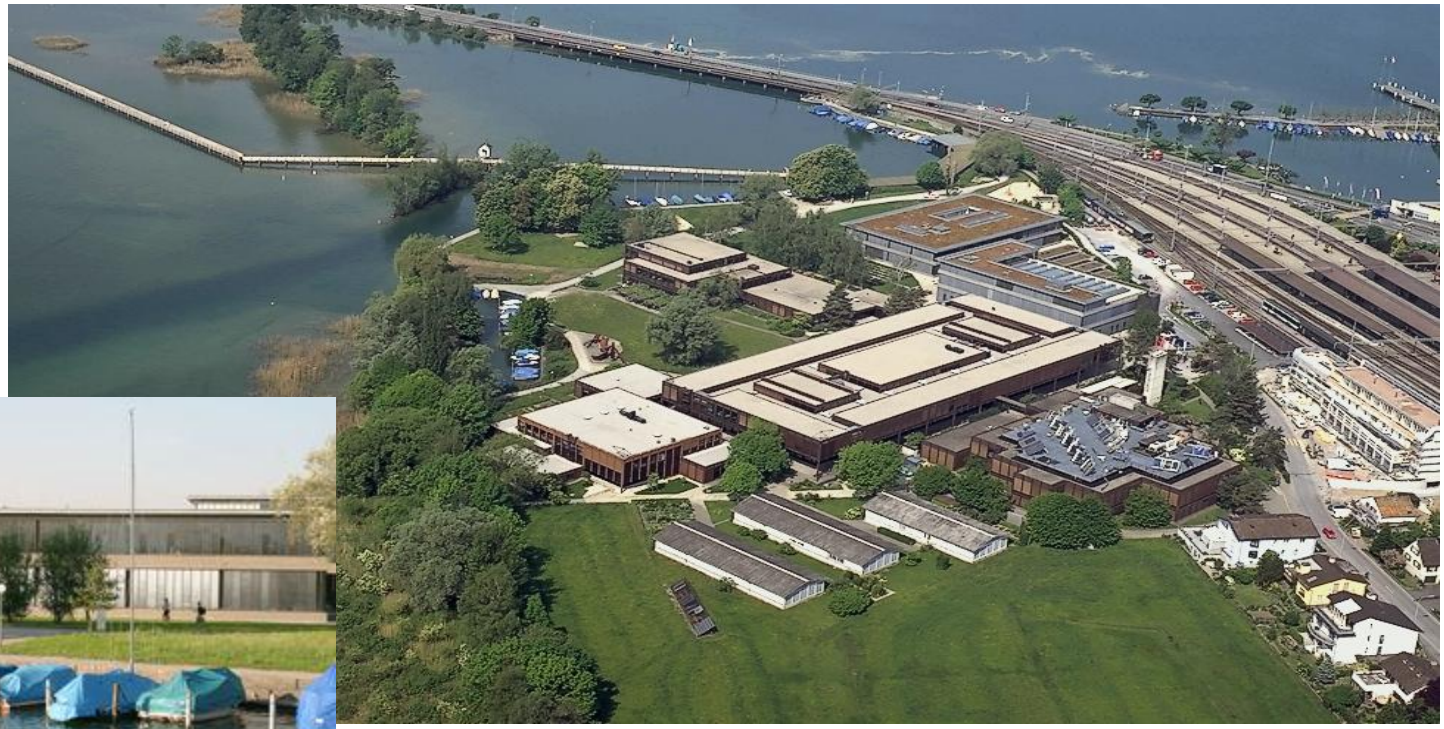
- University of Applied Sciences with about 1000 students
- Faculty of Information Technology (300-400 students)
- Bachelor Course (3 years), Master Course (+1.5 years)



Agenda

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- What is strongSwan?
- IKEv1 versus IKEv2
- A Simple Remote Access Example
- Virtual IP Pools
- Certificate Revocation Mechanisms
- The NETKEY IPsec Stack of the Linux 2.6 Kernel
- Interaction with the Linux Netfilter Firewall
- Dead Peer Detection (DPD)
- Remote Access with Mixed Authentication
- Interoperability with the Windows 7 Agile VPN Client
- The strongSwan NetworkManager Plugin
- EAP-Radius based Authentication
- The strongSwan Architecture
- Cryptographic Plugins
- High Availability using Cluster IP
- IKEv2 Mediation Extension

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What is strongSwan?

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VPN Usage Scenarios

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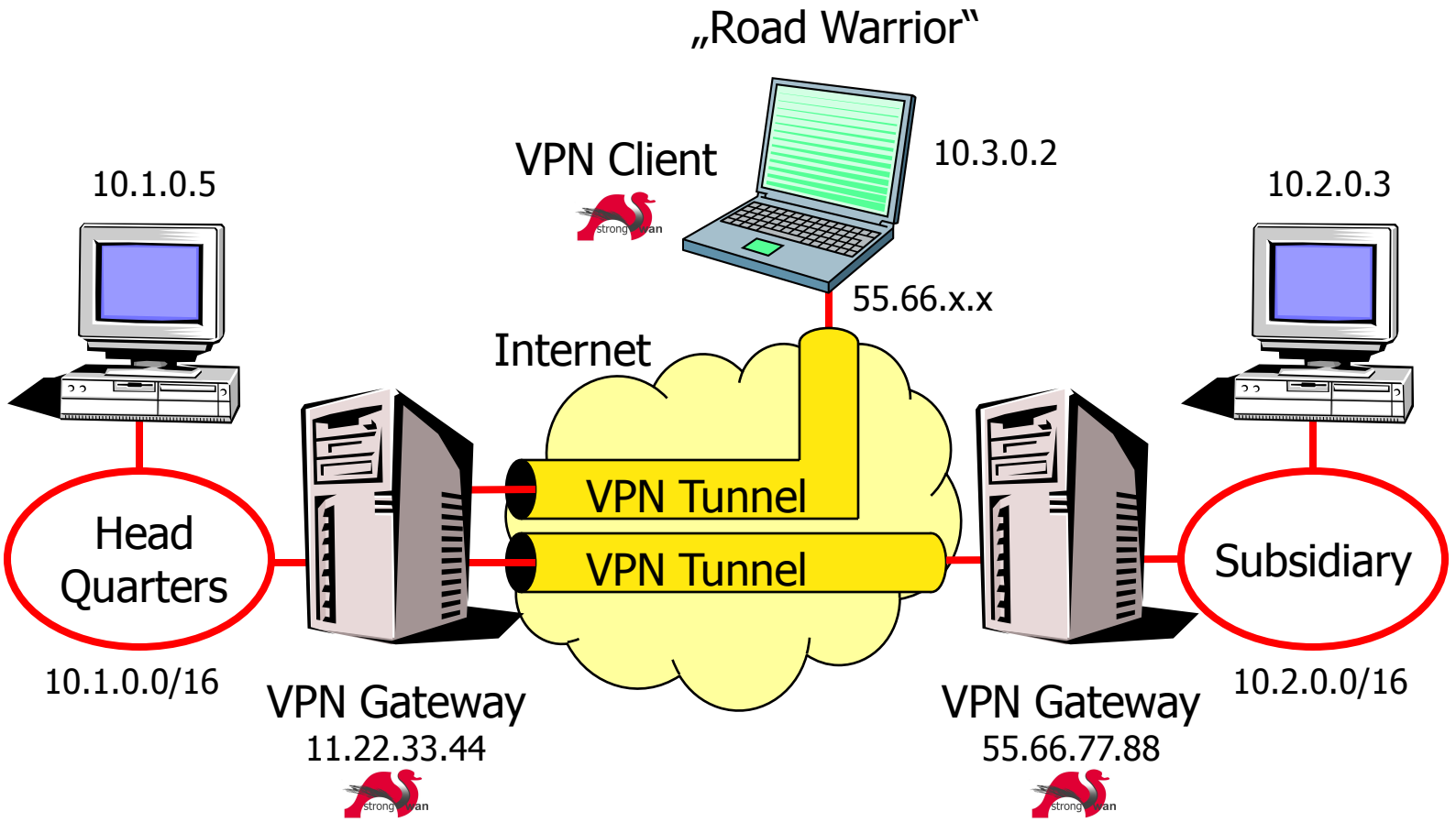

- strongSwan is an Internet Key Exchange daemon needed to automatically set up IPsec-based VPN connections.

The FreeS/WAN Genealogy

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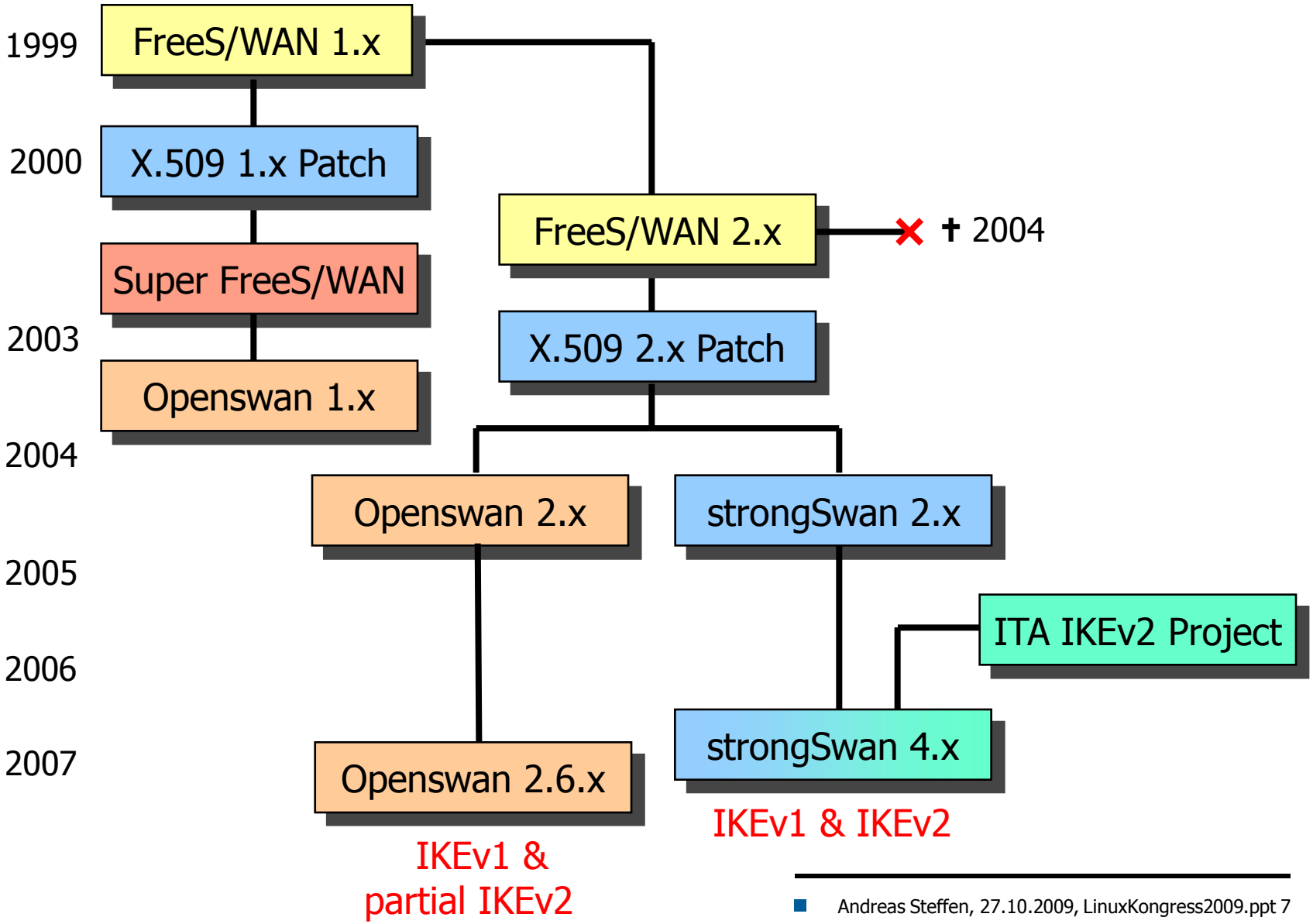

The strongSwan IKE Daemons

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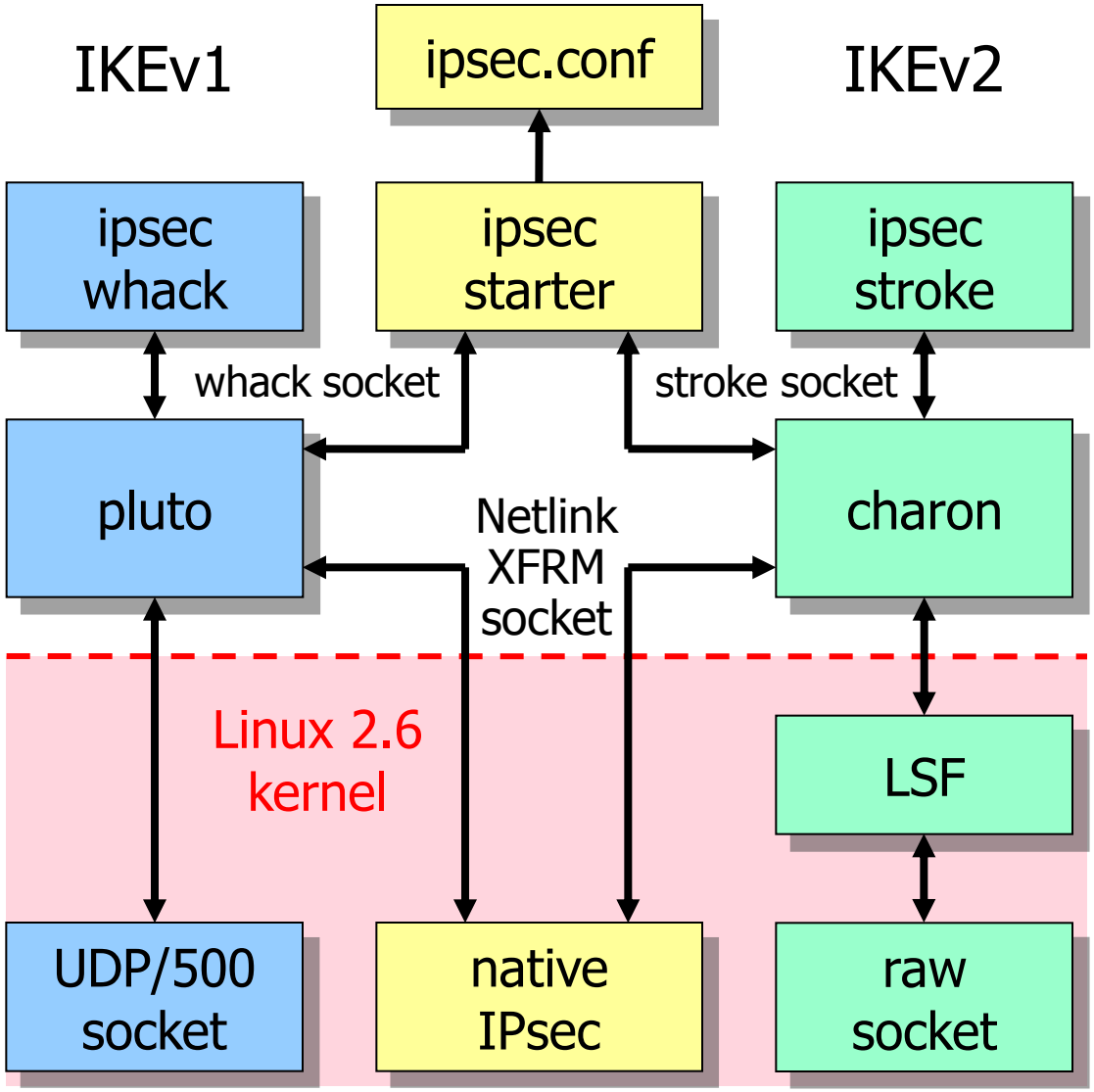

- IKEv1
  - 6 messages for IKE SA
    Phase 1 Main Mode
  - 3 messages for IPsec SA
    Phase 2 Quick Mode
- IKEv2
  - 4 messages for IKE SA and first IPsec SA
    IKE_SA_INIT/IKE_AUTH
  - 2 messages for each additional IPsec SA
    CREATE_CHILD_SA

IKEv2 Interoperability Workshops

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Spring 2007 in Orlando, Florida
Spring 2008 in San Antonio, Texas

- strongSwan successfully interoperated with IKEv2 products from Alcatel-Lucent, Certicom, CheckPoint, Cisco, Furukawa, IBM, Ixia, Juniper, Microsoft, Nokia, SafeNet, Secure Computing, SonicWall, and the IPv6 TAHI Project.

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IVEv1 versus IKEv2

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Internet Key Exchange – IKEv1 Main Mode

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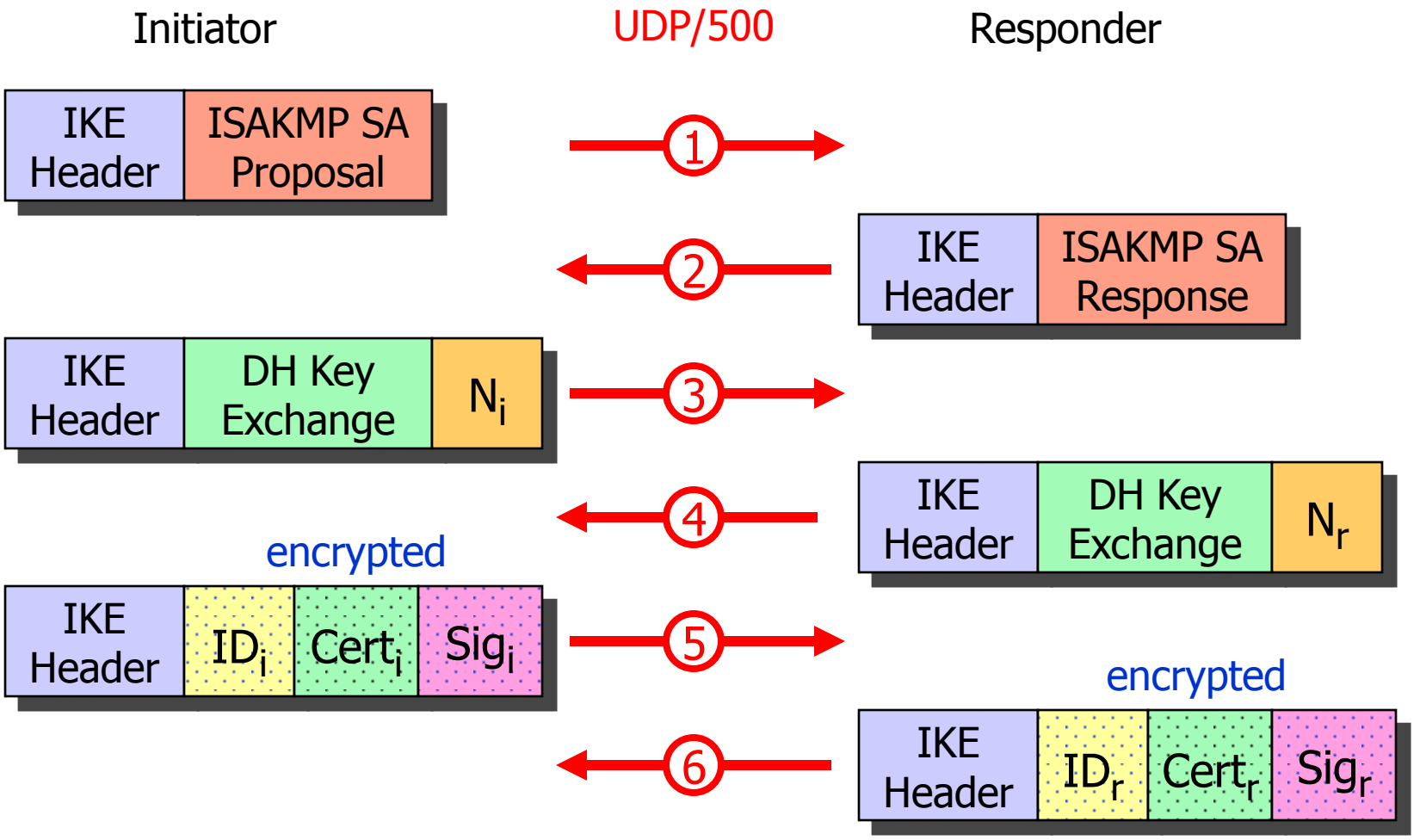

- IKEv1 Quick Mode – another three messages to negotiate traffic selectors

IKEv2 – Authentication and first Child SA

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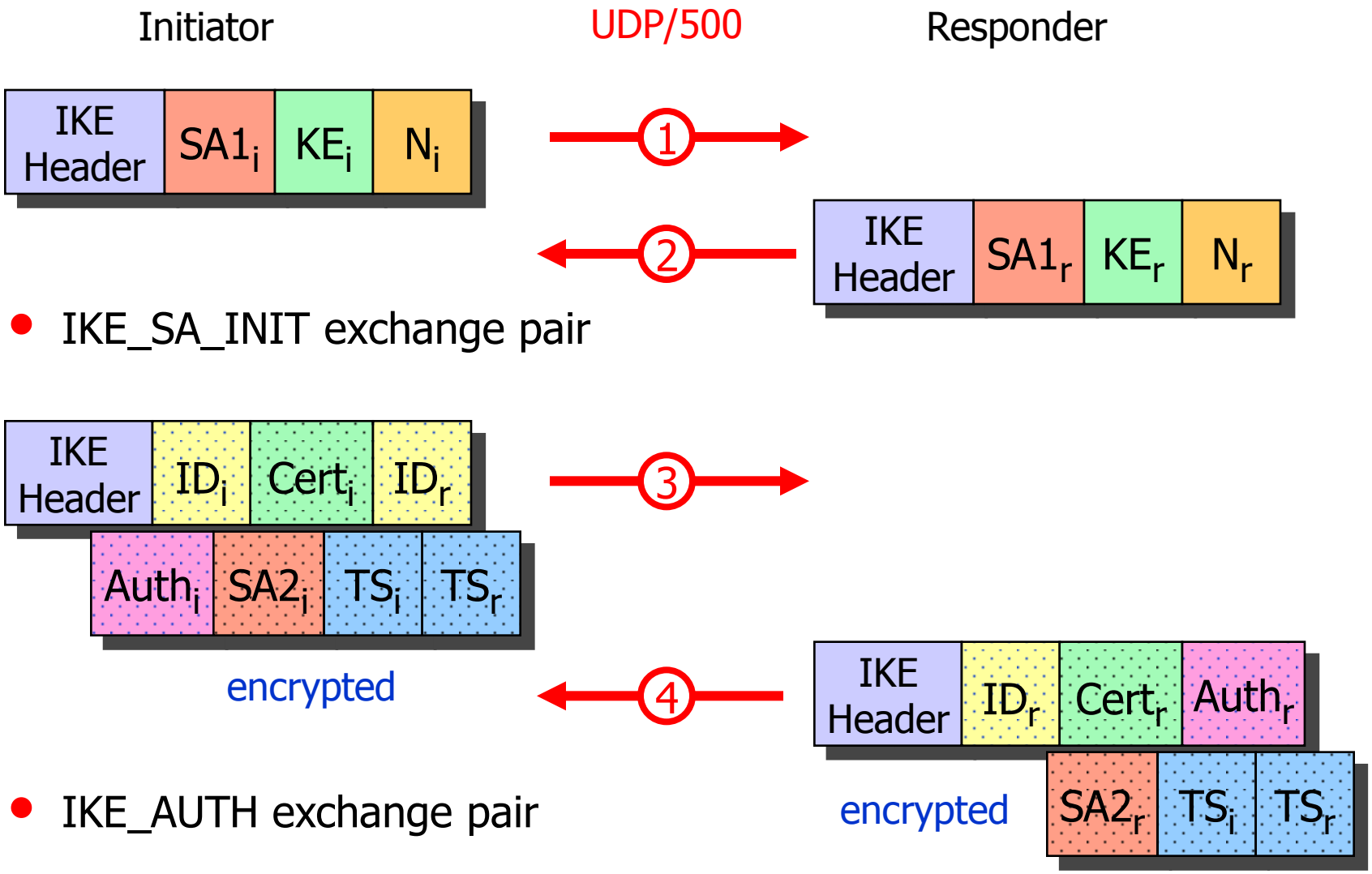

- IKE_SA_INIT exchange pair
- IKE_AUTH exchange pair

IKEv2 – Additional Child SAs

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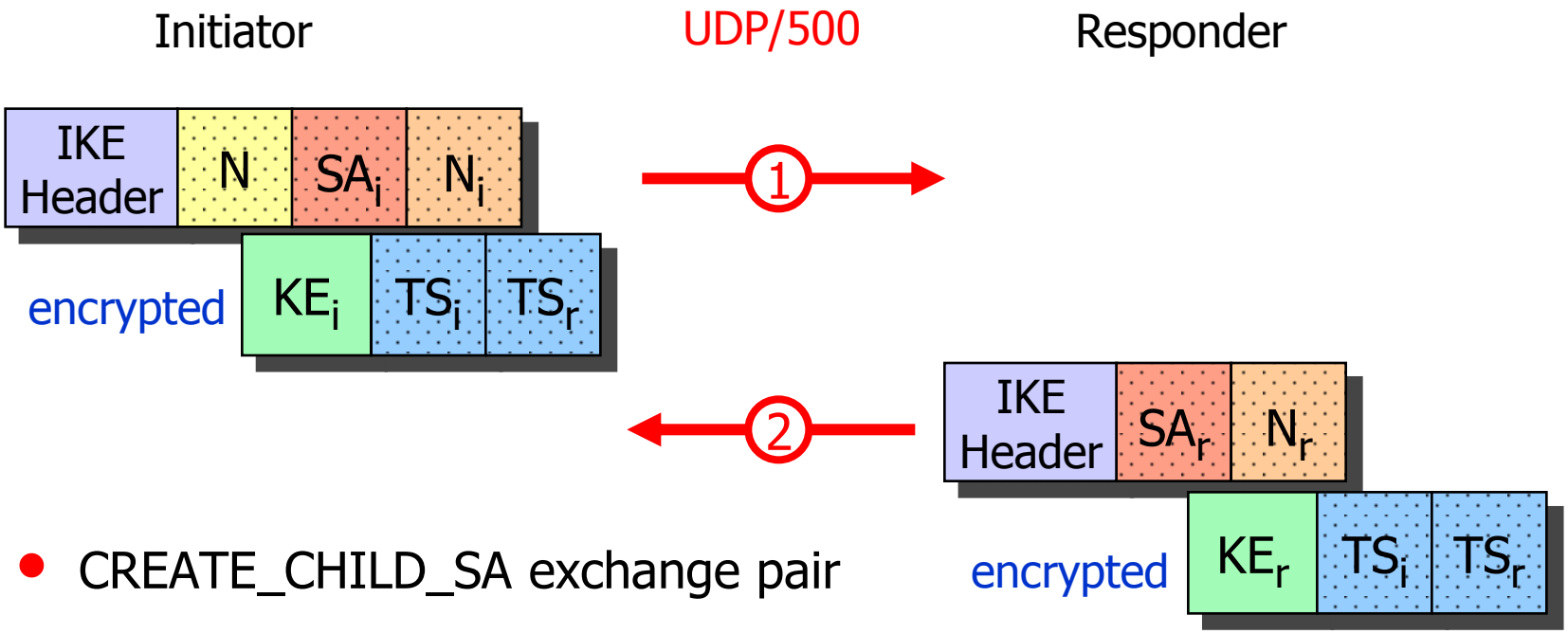

- CREATE_CHILD_SA exchange pair

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A Simple Remote Access Example

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User-Mode-Linux VPN Testbed

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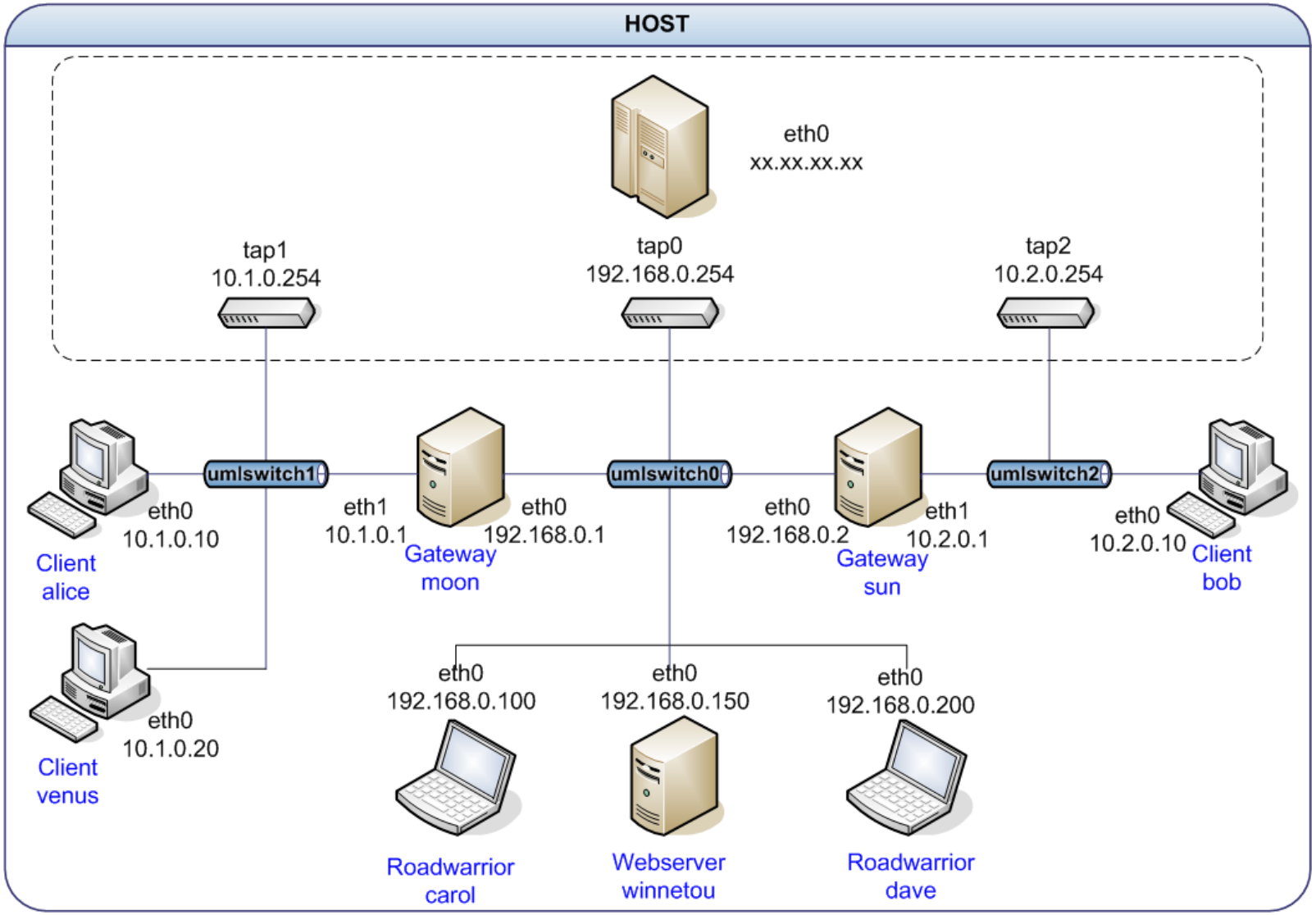

IKEv2 Remote Access Scenario

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```
#ipsec.secrets for roadwarrior carol

: RSA carolKey.pem "nH5ZQEWtku0RJEZ6"
```

```
#ipsec.secrets for gateway moon

: RSA moonKey.pem
```

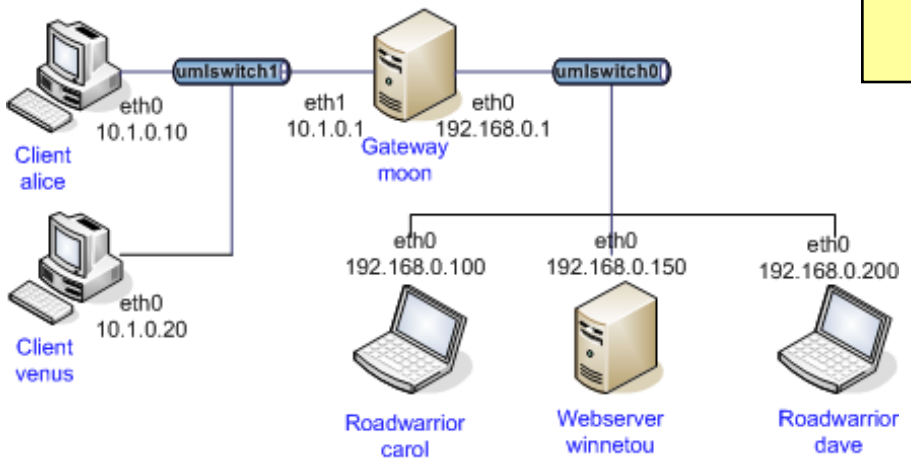
```
#ipsec.conf for roadwarrior carol

conn home
      keyexchange=ikev2
      left=%defaultroute
      leftsourceip=%config
      leftcert=carolCert.pem
      leftid=carol@strongswan.org
      leftfirewall=yes
      right=192.168.0.1
      rightid=@moon.strongswan.org
      rightsubnet=10.1.0.0/16
      auto=start
```

```
#ipsec.conf for gateway moon

config setup
      plutostart=no #IKEv1 not needed

conn rw
      keyexchange=ikev2
      left=%any
      leftsubnet=10.1.0.0/24
      leftcert=moonCert.pem
      leftid=@moon.strongswan.org
      leftfirewall=yes
      right=%any
      rightsourceip=10.3.0.0/24
      auto=add
```



IKEv2 Connection Setup

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carol

```
05[ENC] generating IKE_SA_INIT request [SA KE No N(NATD_S_IP) N(NATD_D_IP)]
05[NET] sending packet: from 192.168.0.100[500] to 192.168.0.1[500]
06[NET] received packet: from 192.168.0.1[500] to 192.168.0.100[500]
06[ENC] parsed IKE_SA_INIT response [SA KE No N(NATD_S_IP) N(NATD_D_IP) CERTREQ]
06[ENC] generating IKE_AUTH request [IDi CERT CERTREQ IDr AUTH CP SA TSi TSr]
06[NET] sending packet: from 192.168.0.100[500] to 192.168.0.1[500]
07[NET] received packet: from 192.168.0.1[500] to 192.168.0.100[500]
07[ENC] parsed IKE_AUTH response [IDr CERT AUTH CP SA TSi TSr N(AUTH_LFT)]
07[IKE] installing new virtual IP 10.3.0.1
07[AUD] established CHILD_SA successfully
```

moon

```
05[NET] received packet: from 192.168.0.100[500] to 192.168.0.1[500]
05[ENC] parsed IKE_SA_INIT request [SA KE No N(NATD_S_IP) N(NATD_D_IP)]
05[ENC] generating IKE_SA_INIT response [SA KE No N(NATD_S_IP) N(NATD_D_IP) CERTREQ]
05[NET] sending packet: from 192.168.0.1[500] to 192.168.0.100[500]
06[NET] received packet: from 192.168.0.100[500] to 192.168.0.1[500]
06[ENC] parsed IKE_AUTH request [IDi CERT CERTREQ IDr AUTH CP SA TSi TSr]
06[IKE] peer requested virtual IP %any
06[IKE] assigning virtual IP 10.3.0.1 to peer
06[AUD] established CHILD_SA successfully
06[ENC] generating IKE_AUTH response [IDr CERT AUTH CP SA TSi TSr N(AUTH_LFT)]
06[NET] sending packet: from 192.168.0.1[500] to 192.168.0.100[500]
```

- No port floating to 4500 with mobike=no

IKEv2 Connection Setup with MOBIKE

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carol

```
05[ENC] generating IKE_SA_INIT request [SA KE No N(NATD_S_IP) N(NATD_D_IP)]
05[NET] sending packet: from 192.168.0.100[500] to 192.168.0.1[500]
06[NET] received packet: from 192.168.0.1[500] to 192.168.0.100[500]
06[ENC] parsed IKE_SA_INIT response [SA KE No N(NATD_S_IP) N(NATD_D_IP) CERTREQ]
06[ENC] generating IKE_AUTH request [IDi .. N(MOBIKE_SUP) N(ADD_6_ADDR)]
06[NET] sending packet: from 192.168.0.100[4500] to 192.168.0.1[4500]
07[NET] received packet: from 192.168.0.1[4500] to 192.168.0.100[4500]
07[ENC] parsed IKE_AUTH response [IDr .. N(MOBIKE_SUP) N(ADD_4_ADDR) N(ADD_6_ADDR)+]
07[IKE] installing new virtual IP 10.3.0.1
07[AUD] established CHILD_SA successfully
```

moon

```
05[NET] received packet: from 192.168.0.100[500] to 192.168.0.1[500]
05[ENC] parsed IKE_SA_INIT request [SA KE No N(NATD_S_IP) N(NATD_D_IP)]
05[ENC] generating IKE_SA_INIT response [SA KE No N(NATD_S_IP) N(NATD_D_IP) CERTREQ]
05[NET] sending packet: from 192.168.0.1[500] to 192.168.0.100[500]
06[NET] received packet: from 192.168.0.100[4500] to 192.168.0.1[4500]
06[ENC] parsed IKE_AUTH request [IDi .. N(MOBIKE_SUP) N(ADD_6_ADDR)]
06[IKE] peer requested virtual IP %any
06[IKE] assigning virtual IP 10.3.0.1 to peer
06[AUD] established CHILD_SA successfully
06[ENC] generating IKE_AUTH resp [IDr .. N(MOBIKE_SUP) N(ADD_4_ADDR) N(ADD_6_ADDR)+]
06[NET] sending packet: from 192.168.0.1[4500] to 192.168.0.100[4500]
```

- Port floating to 4500 by default

Narrowing Traffic Selectors

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carol

```
carol> ipsec statusall

Connections:
  home:  192.168.0.100...192.168.0.1
  home:   local:  [carol@strongswan.org] uses public key authentication
  home:    cert:  "C=CH, O=Linux strongSwan, OU=Research, CN=carol@strongswan.org"
  home:   remote: [moon.strongswan.org] uses any authentication
  home:   child:  dynamic === 10.1.0.0/16
Security Associations:
  home[1]: ESTABLISHED 14 seconds ago, 192.168.0.100[carol@strongswan.org]...
                                       192.168.0.1[moon.strongswan.org]
  home[1]: IKE SPIs: 23b9b14113e91e86_i* 0315c61d96ef0a4f_r, reauth. in 2 hours
  home[1]: IKE proposal: AES_CBC_128/HMAC_SHA1_96/PRF_HMAC_SHA1/MODP_2048
  home{1}:  INSTALLED, TUNNEL, ESP SPIs: cb342ccc_i c9d6623b_o
  home{1}:  AES_CBC_128/HMAC_SHA1_96, 84 bytes_i (10s ago), 84 bytes_o (10s ago),
  home{1}:   10.3.0.1/32 === 10.1.0.0/24
```

- In the most extreme case the remote access client just proposes the widest possible traffic selector of 0.0.0.0/0 and lets the VPN gateway decide which networks and protocols to grant access to.

IKEv2 Configuration Payload

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carol

```
carol> ip addr list dev eth0
eth0: inet 192.168.0.100/24 brd 192.168.0.255 scope global eth0
      inet 10.3.0.1/32 scope global eth0

carol> ip route list table 220
10.1.0.0/24 dev eth0 proto static src 10.3.0.1
```

- A virtual IP requested and obtained through leftsourceip=%config is directly configured by strongSwan via the RT Netlink socket

moon

```
moon> ip addr list
eth0: inet 192.168.0.1/24 brd 192.168.0.255 scope global eth0
eth1: inet 10.1.0.1/16 brd 10.1.255.255 scope global eth1

moon> ip route list table 220
10.3.0.1 dev eth0 proto static src 10.1.0.1
```

- If a host has an internal interface which is part of the negotiated traffic selectors then this source address is assigned to tunneled IP packets.

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Virtual IP Address Pools

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Volatile RAM-based IP Address Pools

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- Configuration in ipsec.conf

```
conn rw
     keyexchange=ikev2
     ...
     rightsourceip=10.3.0.0/24
     auto=add
```

- Statistics

```
ipsec leases

Leases in pool 'rw', usage: 2/255, 2 online
         10.3.0.2   online   'dave@strongswan.org'
         10.3.0.1   online   'carol@strongswan.org'
```

- Referencing and sharing a volatile pool

```
conn rw1
     keyexchange=ikev2
     ...
     rightsourceip=%rw
     auto=add
```

Persistant SQL-based IP Address Pools I

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- SQLite database table definitions

```
http://wiki.strongswan.org/repositories/entry/strongswan/
            testing/hosts/default/etc/ipsec.d/tables.sql
```

- Creation of SQLite database

```
cat /etc/ipsec.d/table.sql | sqlite3 /etc/ipsec.d/ipsec.db
```

- Connecting to the SQLite database

```
# /etc/strongswan.conf - strongSwan configuration file

libstrongswan {
  plugins {
    attr-sql {
      database = sqlite:///etc/ipsec.d/ipsec.db
    }
  }
}
```

Persistant SQL-based IP Address Pools II

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- Pool creation

```
ipsec pool --add bigpool --start 10.3.0.1 --end 10.3.0.254 --timeout 48
allocating 254 addresses... done.
```

- Configuration in ipsec.conf

```
conn rw
     keyexchange=ikev2
     ...
     rightsourceip=%bigpool
     auto=add
```

- Statistics

```
ipsec pool --status
name      start       end           timeout  size     online     usage
bigpool   10.3.0.1    10.3.0.254    48h      254      1 ( 0%)    2 ( 0%)

ipsec pool --leases --filter pool=bigpool
name      address  status start                end                  identity
bigpool   10.3.0.1 online Oct 22 23:13:50 2009                     carol@strongswan.org
bigpool   10.3.0.2 valid  Oct 22 23:14:11 2009 Oct 22 23:14:25 2009 dave@strongswan.org
```

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Certificate Revocation Mechanisms

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HTTP or LDAP based CRL Fetching

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crlDistributionPoints extension in user certificate

```
crlDistributionPoints = URI:http://crl.strongswan.org/strongswan.crl
```

```
# ipsec.conf

config setup
    strictcrlpolicy=yes
    cachecrls=yes

ca strongswan
    cacert=strongswanCert.pem
    crluri="ldap://ldap.strongswan.org/cn=strongSwan Root CA,
                    o=Linux strongSwan, c=CH?certificateRevocationList"
    auto=add
```

```
13[CFG] checking certificate status of "C=CH, O=Linux strongSwan, OU=Research,
                                       CN=carol@strongswan.org"
13[CFG]   fetching crl from 'http://crl.strongswan.org/strongswan.crl' ...
13[CFG]   using trusted certificate "C=CH, O=Linux strongSwan,
                                       CN=strongSwan Root CA"
13[CFG]   crl correctly signed by "C=CH, O=Linux strongSwan,
                                       CN=strongSwan Root CA"
13[CFG]   crl is valid: until Nov 15 22:42:42 2009
13[CFG] certificate status is good
13[LIB]   written crl file '/etc/ipsec.d/crls/5da7...4def.crl' (942 bytes)
```

Online Certificate Status Protocol (OCSP)
with self-signed OCSP certificate

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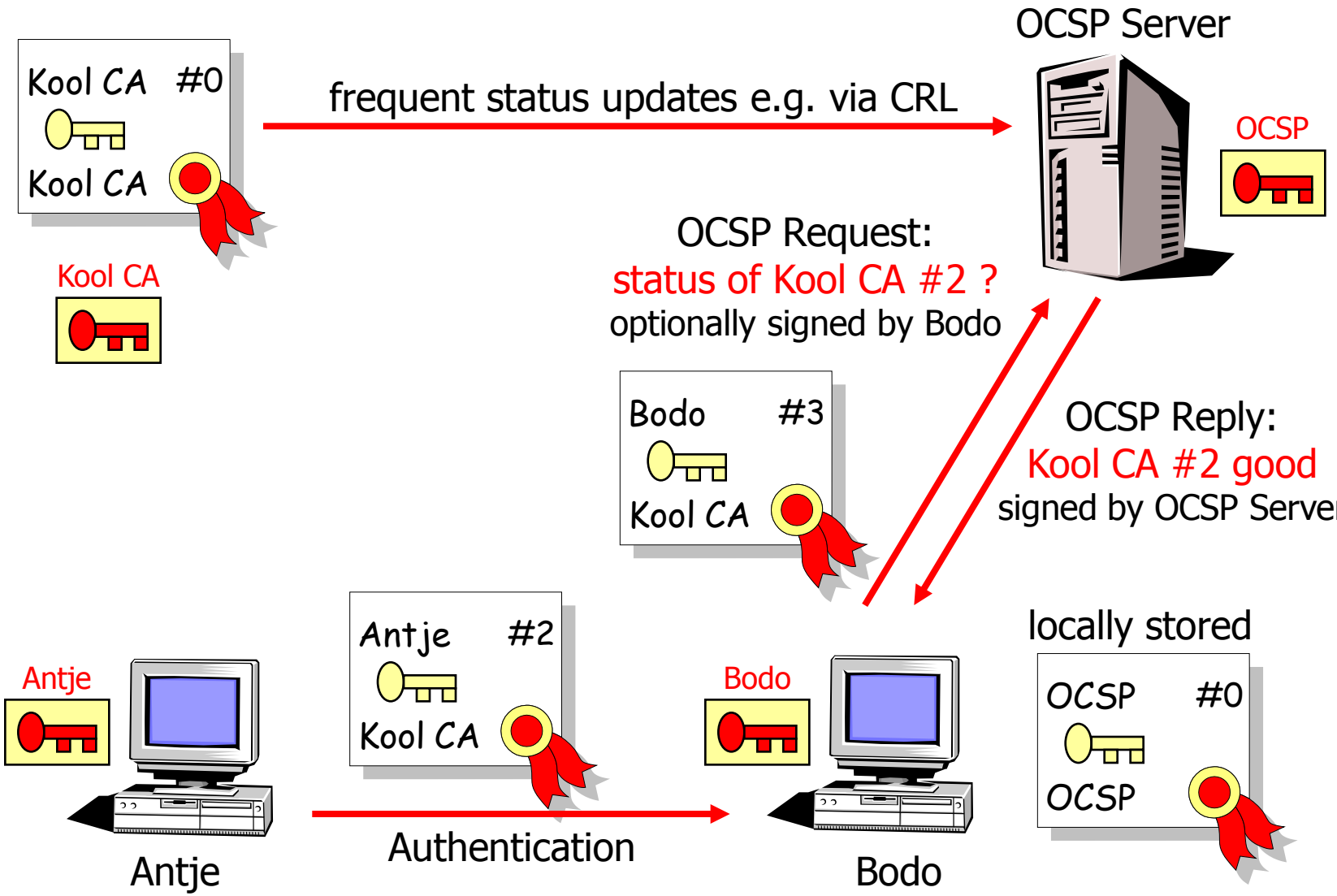

OCSP with self-signed OCSP Certificate

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moon

```
# /etc/ipsec.conf

ca strongswan
    cacert=strongswanCert.pem
    ocspuri=http://ocsp.strongswan.org:8880
    auto=add
```

```
13[CFG] checking certificate status of "C=CH, O=Linux strongSwan,
                                OU=Research, CN=carol@strongswan.org"
13[CFG]   requesting ocsp status from 'http://ocsp.strongswan.org:8880' ...
13[CFG]   using trusted certificate "C=CH, O=Linux strongSwan,
              OU=OCSP Self-Signed Authority, CN=ocsp.strongswan.org"
13[CFG]   ocsp response correctly signed by "C=CH, O=Linux strongSwan,
              OU=OCSP Self-Signed Authority, CN=ocsp.strongswan.org"
13[CFG]   ocsp response is valid: until Oct 17 02:11:09 2009
13[CFG] certificate status is good
```

```
ipsec listcainfos
  authname:     "C=CH, O=Linux strongSwan, CN=strongSwan Root CA"
  authkey:       5d:a7:dd:70:06:51:32:7e:e7:b6:6d:b3:b5:e5:e0:60:ea:2e:4d:ef
  keyid:         ae:09:6b:87:b4:48:86:d3:b8:20:97:86:23:da:bd:0e:ae:22:eb:bc
  ocspuris:     'http://ocsp.strongswan.org:8880'
```

Online Certificate Status Protocol (OCSP)
with delegated trust

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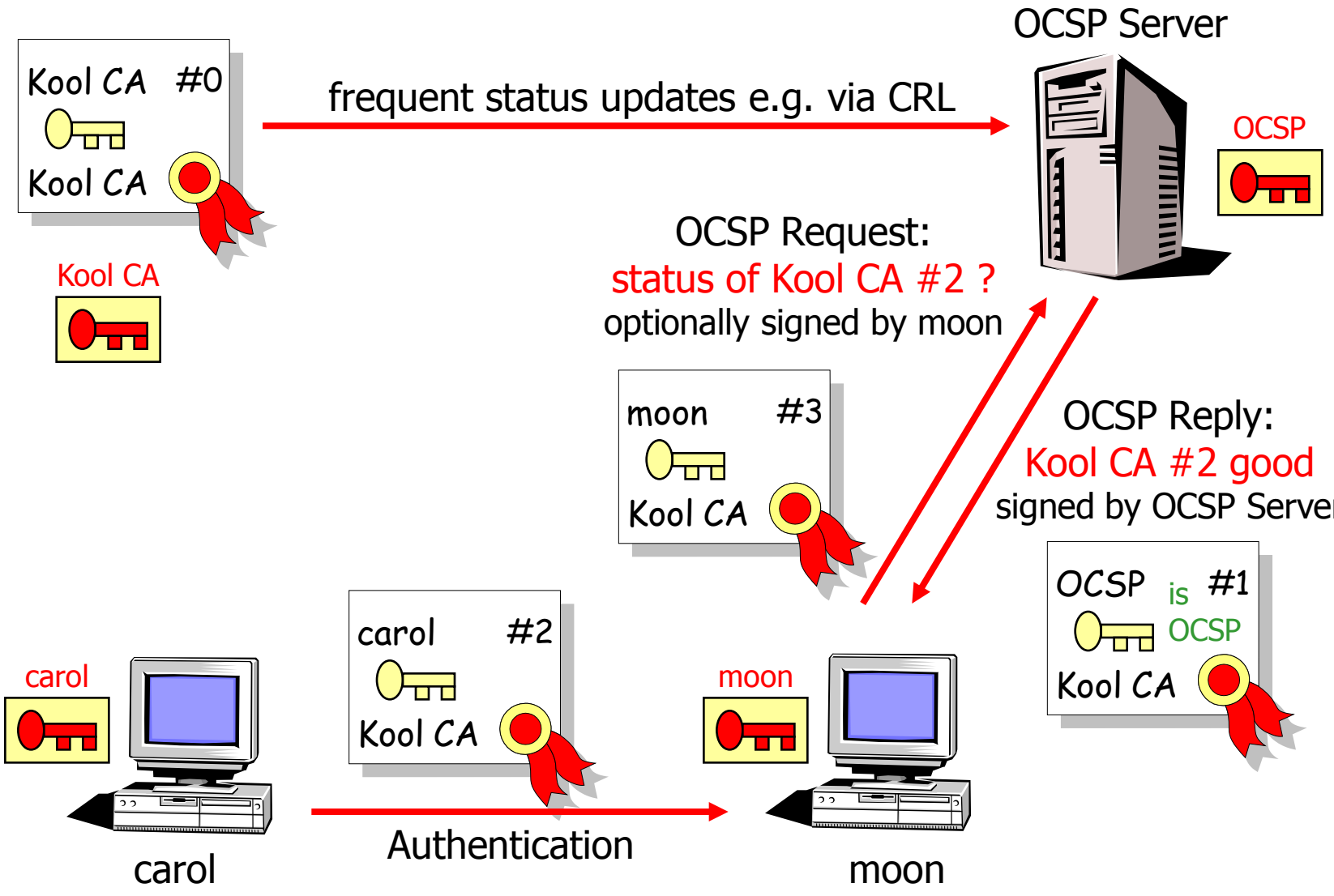

OCSP with Delegated Trust

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extendedKeyUsage flag in OCSP-signer certificate

```
extendedKeyUsage = OCSPSigning
```

carol: authorityInfoAccess extension in user certificate

```
authorityInfoAccess = OCSP;URI:http://ocsp.strongswan.org:8880
```

moon

```
11[CFG] checking certificate status of "C=CH, O=Linux strongSwan,
                              OU=OCSP, CN=carol@strongswan.org"
11[CFG]   requesting ocsp status from 'http://ocsp.strongswan.org:8880' ...
11[CFG]   using certificate "C=CH, O=Linux strongSwan,
             OU=OCSP Signing Authority, CN=ocsp.strongswan.org"
11[CFG]   using trusted ca certificate "C=CH, O=Linux strongSwan,
                                        CN=strongSwan Root CA"
11[CFG]   ocsp response correctly signed by "C=CH, O=Linux strongSwan,
             OU=OCSP Signing Authority, CN=ocsp.strongswan.org"
11[CFG]   ocsp response is valid: until Oct 17 02:13:21 2009
11[CFG] certificate status is good
```

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The NETKEY IPsec Stack of the Linux 2.6 Kernel

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IPsec Tunnel Mode using ESP

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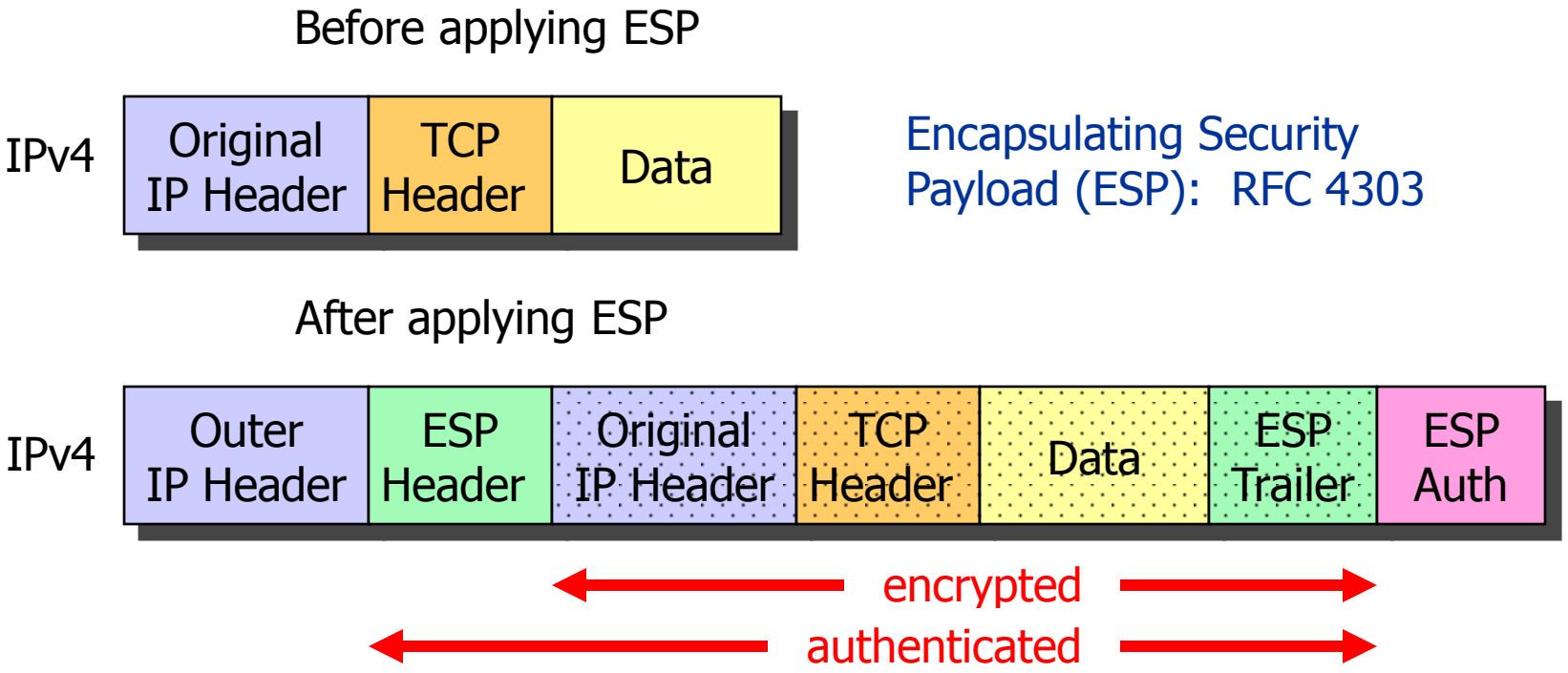

- IP protocol number for ESP: 50
- ESP authentication is optional but often used in place of AH
- Original IP Header is encrypted and therefore hidden

ESP Header (Header / Payload / Trailer)

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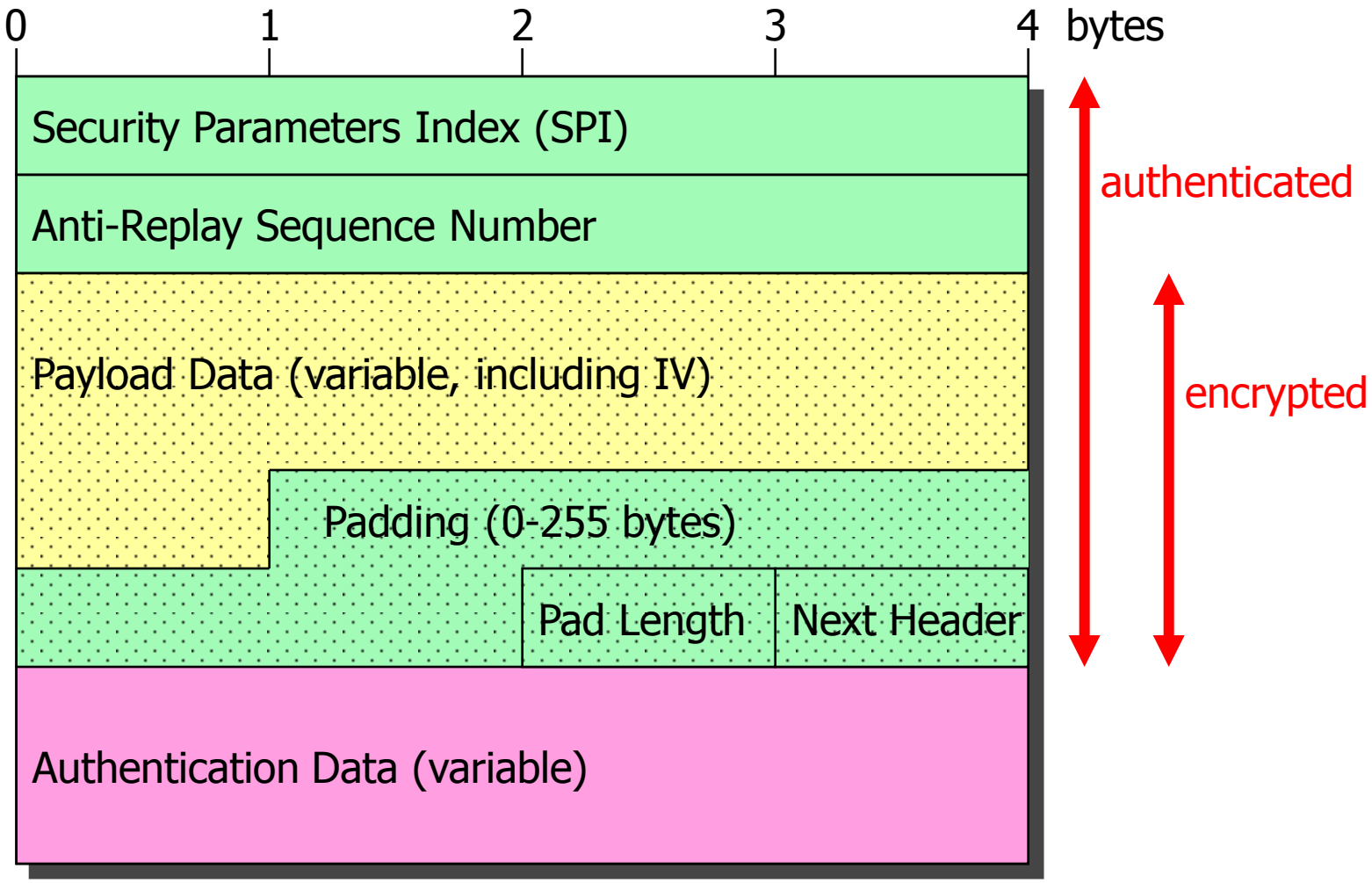

Authenticated Encryption with Associated Data

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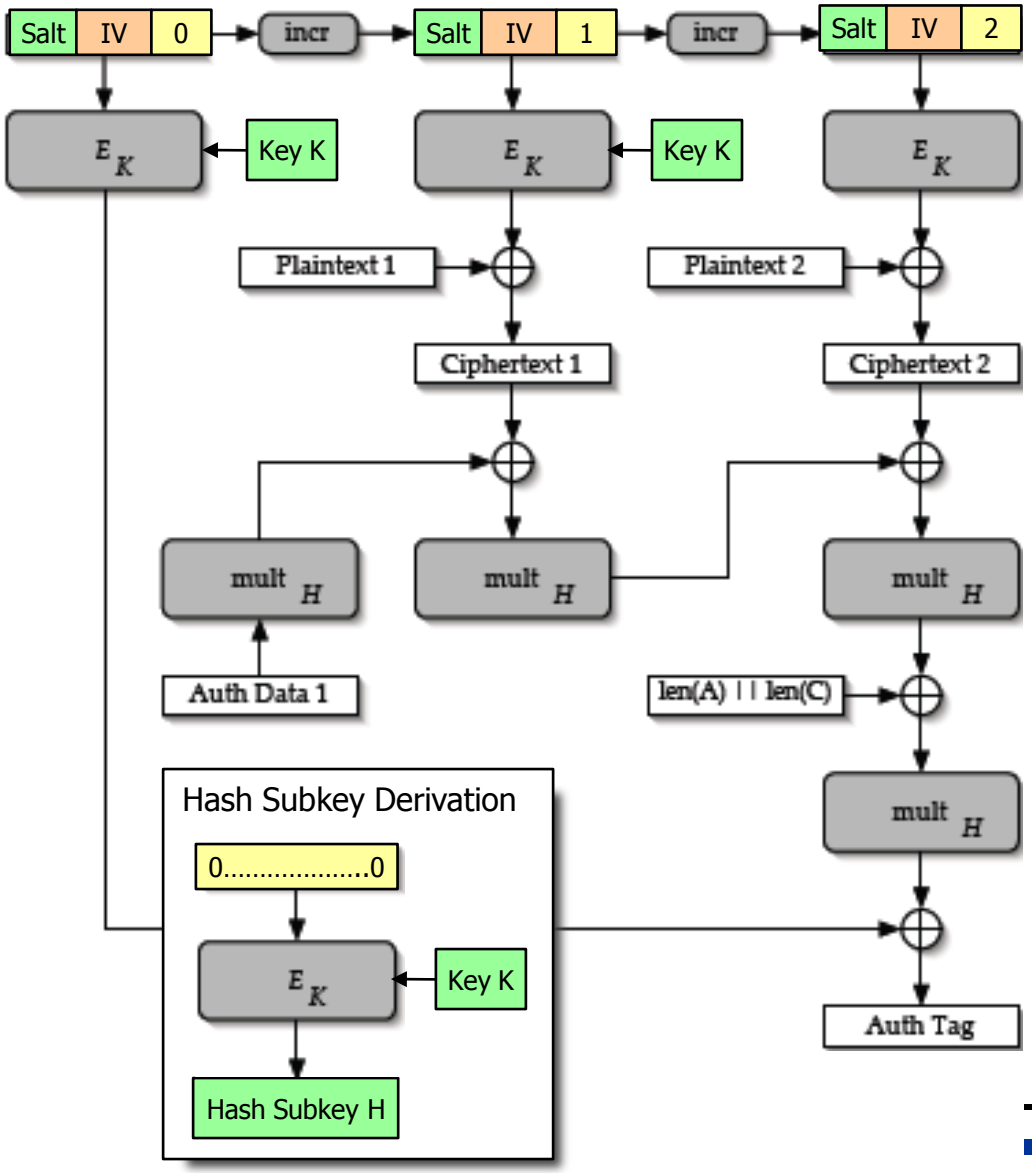

- AEAD is based on special block cipher modes:

- Block size: 128 bits
- Key size: 128/256 bits
- Tag size : 128/96/64 bits
- Nonce size: 128 bits

Salt	IV	Counter
32 bits	64 bits	32 bits

- Recommended AEAD Modes:
  AES-Galois/Counter Mode
  AES-GMAC (auth. only)

- Alternative AEAD Modes:
  AES-CCM
  CAMELLIA-GCM
  CAMELLIA-CCM

IPsec Policies in the Linux Kernel

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carol: ip -s xfrm policy

```
src 10.1.0.0/24 dst 10.3.0.1/32 uid 0
    dir in action allow index 800 priority 1760 ...
    lifetime config:
      limit: soft (INF)(bytes), hard (INF)(bytes)
      limit: soft (INF)(packets), hard (INF)(packets)
      expire add: soft 0(sec), hard 0(sec)
      expire use: soft 0(sec), hard 0(sec)
    lifetime current:
      0(bytes), 0(packets)
      add 2009-10-22 20:34:37 use 2009-10-22 20:34:39
    tmpl src 192.168.0.1 dst 192.168.0.100
        proto esp spi 0x00000000(0) reqid 1(0x00000001) mode tunnel

src 10.3.0.1/32 dst 10.1.0.0/24 uid 0
    dir out action allow index 793 priority 1680 ...
    lifetime config:
      limit: soft (INF)(bytes), hard (INF)(bytes)
      limit: soft (INF)(packets), hard (INF)(packets)
      expire add: soft 0(sec), hard 0(sec)
      expire use: soft 0(sec), hard 0(sec)
    lifetime current:
      0(bytes), 0(packets)
      add 2009-10-22 20:34:37 use 2009-10-22 20:34:38
    tmpl src 192.168.0.100 dst 192.168.0.1
        proto esp spi 0x00000000(0) reqid 1(0x00000001) mode tunnel
```

IPsec Policies in the Linux Kernel

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moon: ip -s xfrm policy

```
src 10.3.0.1/32 dst 10.1.0.0/24 uid 0
    dir fwd action allow index 954 priority 1680 ...
    lifetime config:
      limit: soft (INF)(bytes), hard (INF)(bytes)
      limit: soft (INF)(packets), hard (INF)(packets)
      expire add: soft 0(sec), hard 0(sec)
      expire use: soft 0(sec), hard 0(sec)
    lifetime current:
      0(bytes), 0(packets)
      add 2009-10-22 20:34:36 use 2009-10-22 20:34:39
    tmpl src 192.168.0.100 dst 192.168.0.1
        proto esp spi 0x00000000(0) reqid 1(0x00000001) mode tunnel

src 10.1.0.0/24 dst 10.3.0.1/32 uid 0
    dir out action allow index 937 priority 1760 ...
    lifetime config:
      limit: soft (INF)(bytes), hard (INF)(bytes)
      limit: soft (INF)(packets), hard (INF)(packets)
      expire add: soft 0(sec), hard 0(sec)
      expire use: soft 0(sec), hard 0(sec)
    lifetime current:
      0(bytes), 0(packets)
      add 2009-10-22 20:34:36 use 2009-10-22 20:34:39
    tmpl src 192.168.0.1 dst 192.168.0.100
        proto esp spi 0x00000000(0) reqid 1(0x00000001) mode tunnel
```

NETKEY Hooks in Linux Netfilter

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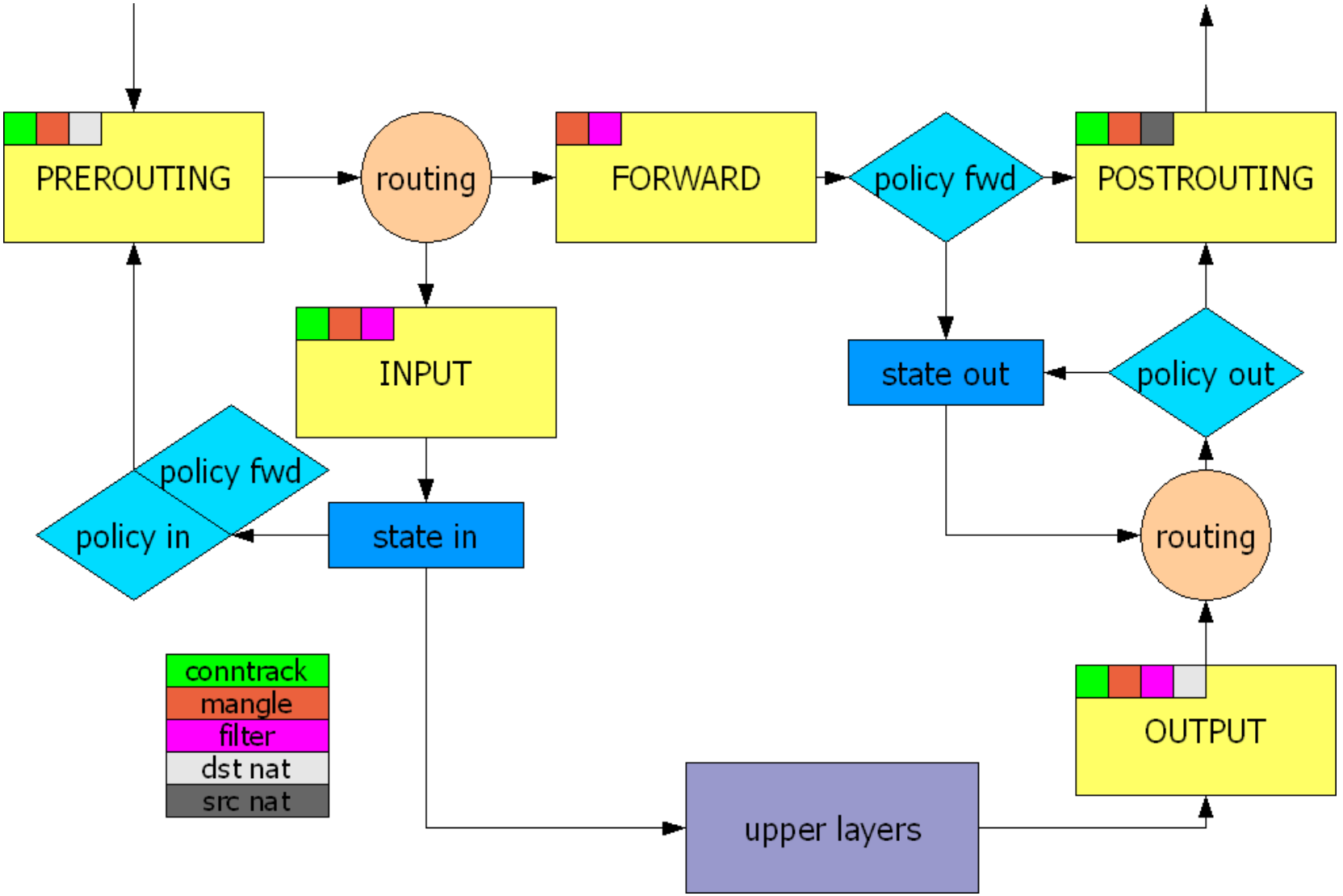

IKE SA and IPsec SA Rekeying Criteria

Institute for Internet Technologies and Applications

```
#ipsec.conf

conn %default
   ikelifetime=180m          # default 180m
   lifetime=60m              # default  60m
   lifebytes=500000000       # default   0   (no hard limit)
   lifepackets=1000000       # default   0   (no hard limit)
   margintime=6m             # default   9m
   marginbytes=50000000      # default   0   (no soft limit)
   marginpackets=100000      # default   0   (no soft limit)
   rekeyfuzz=50%             # default 100%
   keyingtries=1             # default   0   (forever)
   rekey=yes                 # default  yes
   reauth=no                 # default  yes
```

Legacy parameters:

- keylife: synonym for lifetime
- rekeymargin: synonym for margintime

IPsec Security Associations in the Kernel

Institute for Internet Technologies and Applications

carol: ip -s xfrm state

```
src 192.168.0.100 dst 192.168.0.1
    proto esp spi 0xc77ca4c3(3346834627) reqid 1(0x00000001) mode tunnel
    replay-window 32 seq 0x00000000 flag 20 (0x00100000)
    auth hmac(sha1) 0x98fe271fd31ba795f158ae17487cb85f8682aefc (160 bits)
    enc cbc(aes) 0x3d0567d65694fcbbfd3257f55b497d6a (128 bits)
    lifetime config:
      limit: soft 445929743(bytes), hard 500000000(bytes)
      limit: soft 871034(packets), hard 1000000(packets)
      expire add: soft 3065(sec), hard 3600(sec)
      expire use: soft 0(sec), hard 0(sec)
    lifetime current:
      84(bytes), 1(packets)
      add 2009-10-22 20:34:37 use 2009-10-22 20:34:38
    stats:
      replay-window 0 replay 0 failed 0

src 192.168.0.1 dst 192.168.0.100
    proto esp spi 0xc46038e1(3294640353) reqid 1(0x00000001) mode tunnel
    replay-window 32 seq 0x00000000 flag 20 (0x00100000)
    auth hmac(sha1) 0x4e2b044e2835297d3f73bbf99289f369ae2d3ed5 (160 bits)
    enc cbc(aes) 0xd2d83f5d7e496ddc9483be57dbbb2757 (128 bits)
    ...
```

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Interaction with the Linux Netfilter Firewall

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Full Integration with Linux Netfilter Firewall

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carol

```
Chain INPUT (policy DROP 0 packets, 0 bytes)
pkts bytes target prot in  out  source       destination
 1     84  ACCEPT all eth0  *    10.1.0.0/24  10.3.0.1
                               policy match dir in  pol ipsec reqid 1 proto 50
 1    152  ACCEPT esp eth0  *    0.0.0.0/0    0.0.0.0/0
 2   2069  ACCEPT udp eth0  *    0.0.0.0/0    0.0.0.0/0    udp spt:500 dpt:500

Chain OUTPUT (policy DROP 0 packets, 0 bytes)
pkts bytes target prot in  out  source       destination
 1     84  ACCEPT all  *   eth0 10.3.0.1     10.1.0.0/24
                               policy match dir out pol ipsec reqid 1 proto 50
 1    152  ACCEPT esp  *   eth0 0.0.0.0/0    0.0.0.0/0
 2   2456  ACCEPT udp  *   eth0 0.0.0.0/0    0.0.0.0/0    udp spt:500 dpt:500
```

- After the successful establishment/deletion of a CHILD_SA the updown plugin dynamically inserts and removes an INPUT and OUTPUT Netfilter IPsec ESP policy matching rule via the iptables command executed by the /usr/libexec/ipsec/_updown shell script.

Full Integration with Linux Netfilter Firewall

Institute for Internet Technologies and Applications

moon

```
Chain INPUT (policy DROP 0 packets, 0 bytes)
pkts bytes target prot in  out  source       destination
 2    304  ACCEPT esp eth0  *    0.0.0.0/0    0.0.0.0/0
 4   4896  ACCEPT udp eth0  *    0.0.0.0/0    0.0.0.0/0   udp spt:500 dpt:500

Chain FORWARD (policy DROP 0 packets, 0 bytes)
pkts bytes target prot in  out  source       destination
 1     84  ACCEPT all eth0  *    10.3.0.2     10.1.0.20
                                 policy match dir in  pol ipsec reqid 2 proto 50
 1     84  ACCEPT all  *   eth0 10.1.0.20    10.3.0.2
                                 policy match dir out pol ipsec reqid 2 proto 50
 1     84  ACCEPT all eth0  *    10.3.0.1     10.1.0.0/24
                                 policy match dir in  pol ipsec reqid 1 proto 50
 1     84  ACCEPT all  * eth0   10.1.0.0/24  10.3.0.1
                                 policy match dir out pol ipsec reqid 1 proto 50

Chain OUTPUT (policy DROP 0 packets, 0 bytes)
pkts bytes target prot in  out  source        destination
 2    304  ACCEPT esp  *   eth0 0.0.0.0/0     0.0.0.0/0
 4   4138  ACCEPT udp  *   eth0 0.0.0.0/0     0.0.0.0/0  udp spt:500 dpt:500
```

- On gateways the updown plugin dynamically inserts and removes two FORWARD Netfilter IPsec ESP policy matching rules per CHILD_SA.
- lefthostaccess=yes additionally adds an input/output rule to access the GW itself.

Static IPsec ESP Policy Matching Rules

Institute for Internet Technologies and Applications

moon

```
Chain INPUT (policy DROP 0 packets, 0 bytes)
pkts bytes target prot in  out  source       destination
 2    304  ACCEPT esp eth0  *    0.0.0.0/0    0.0.0.0/0
 4   4896  ACCEPT udp eth0  *    0.0.0.0/0    0.0.0.0/0   udp spt:500 dpt:500

Chain FORWARD (policy DROP 0 packets, 0 bytes)
pkts bytes target prot in  out  source       destination
 2    168  ACCEPT all  *    *    0.0.0.0/0    0.0.0.0/0
                                 policy match dir in  pol ipsec proto 50
 2    168  ACCEPT all  *    *    0.0.0.0/0     0.0.0.0/0
                                 policy match dir out pol ipsec proto 50

Chain OUTPUT (policy DROP 0 packets, 0 bytes)
pkts bytes target prot in  out  source        destination
 2    304  ACCEPT esp  *    eth0 0.0.0.0/0     0.0.0.0/0
 4   4138  ACCEPT udp  *    eth0 0.0.0.0/0     0.0.0.0/0  udp spt:500 dpt:500
```

- leftfirewall=yes can be omitted and the updown plugin doesn't have to be built (./configure --disable-updown).

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Dead Peer Detection (DPD)

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Activation of Dead Peer Detection

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```
#ipsec.conf for roadwarrior carol

conn %default
     dpddelay=60
     dpdaction=restart
```

```
#ipsec.conf for gateway moon

conn %default
     dpddelay=60
     dpdaction=clear
```

```
Oct 24 11:45:10 13[IKE] CHILD_SA home{1} established with SPIs c50810d9_i c8485f4a_o
Oct 24 11:46:10 16[NET] received packet: from 192.168.0.1[500] to 192.168.0.100[500]
Oct 24 11:46:10 16[ENC] parsed INFORMATIONAL request 0 [ ]
Oct 24 11:46:10 16[ENC] generating INFORMATIONAL response 0 [ ]
Oct 24 11:46:10 16[NET] sending packet: from 192.168.0.100[500] to 192.168.0.1[500]
Oct 24 11:47:09 09[IKE] sending DPD request
Oct 24 11:47:09 09[ENC] generating INFORMATIONAL request 2 [ ]
Oct 24 11:47:09 09[NET] sending packet: from 192.168.0.100[500] to 192.168.0.1[500]
Oct 24 11:47:13 03[IKE] retransmit 1 of request with message ID 2
Oct 24 11:47:13 03[NET] sending packet: from 192.168.0.100[500] to 192.168.0.1[500]
Oct 24 11:47:20 11[IKE] retransmit 2 of request with message ID 2
Oct 24 11:47:20 11[NET] sending packet: from 192.168.0.100[500] to 192.168.0.1[500]
Oct 24 11:47:33 08[IKE] retransmit 3 of request with message ID 2
Oct 24 11:47:33 08[NET] sending packet: from 192.168.0.100[500] to 192.168.0.1[500]
Oct 24 11:47:56 12[IKE] retransmit 4 of request with message ID 2
Oct 24 11:47:56 12[NET] sending packet: from 192.168.0.100[500] to 192.168.0.1[500]
Oct 24 11:48:38 14[IKE] retransmit 5 of request with message ID 2
Oct 24 11:48:38 14[NET] sending packet: from 192.168.0.100[500] to 192.168.0.1[500]
Oct 24 11:49:54 16[IKE] giving up after 5 retransmits
Oct 24 11:49:54 16[IKE] restarting CHILD_SA home
Oct 24 11:49:54 16[IKE] initiating IKE_SA home[2] to 192.168.0.1
```

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Remote-Access with Mixed Authentication

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IKEv1 Main Mode using Pre-Shared Keys

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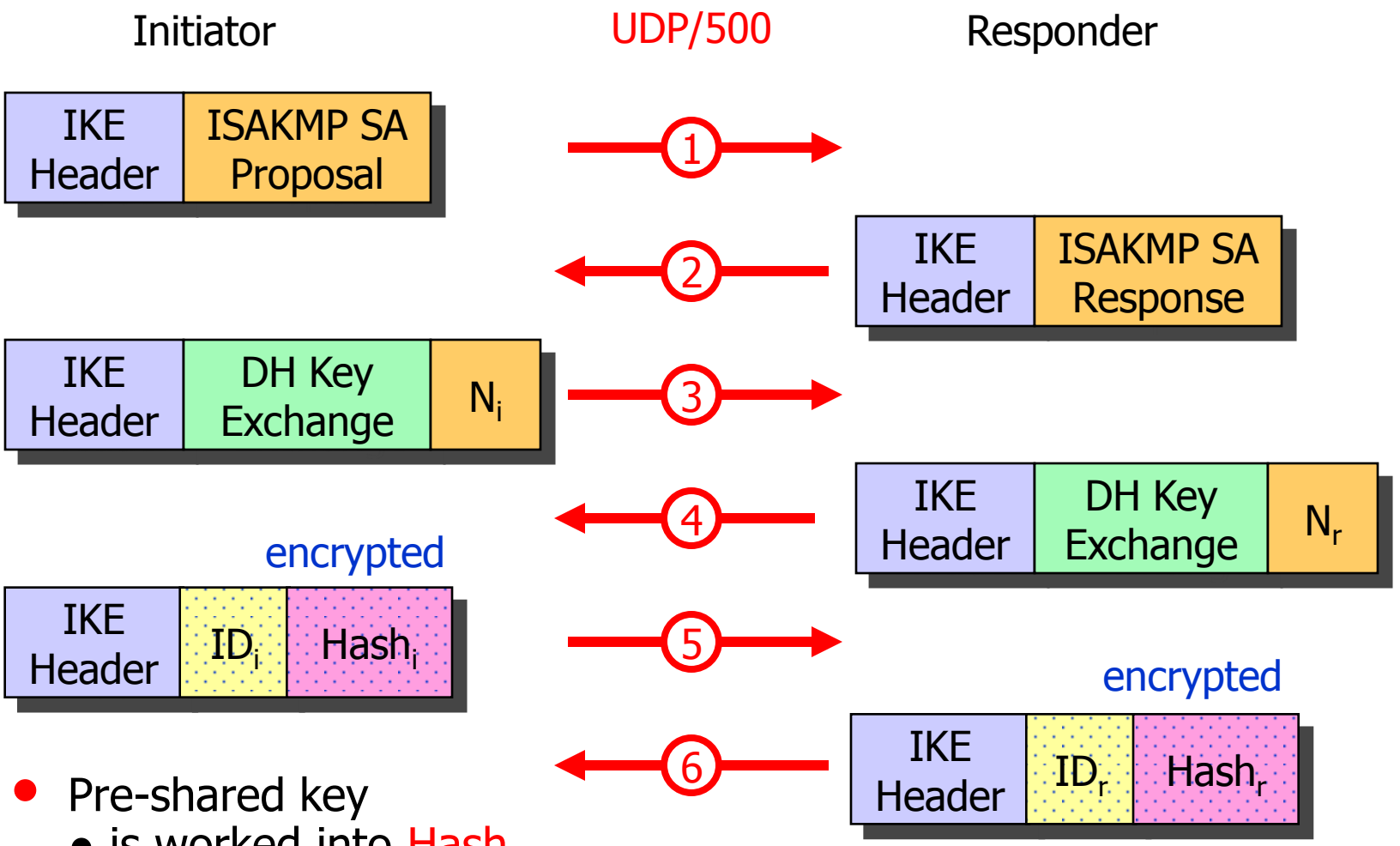

- Pre-shared key
  - is worked into Hash
  - is part of the IKE session key

IKEv1 Aggressive Mode using PSK

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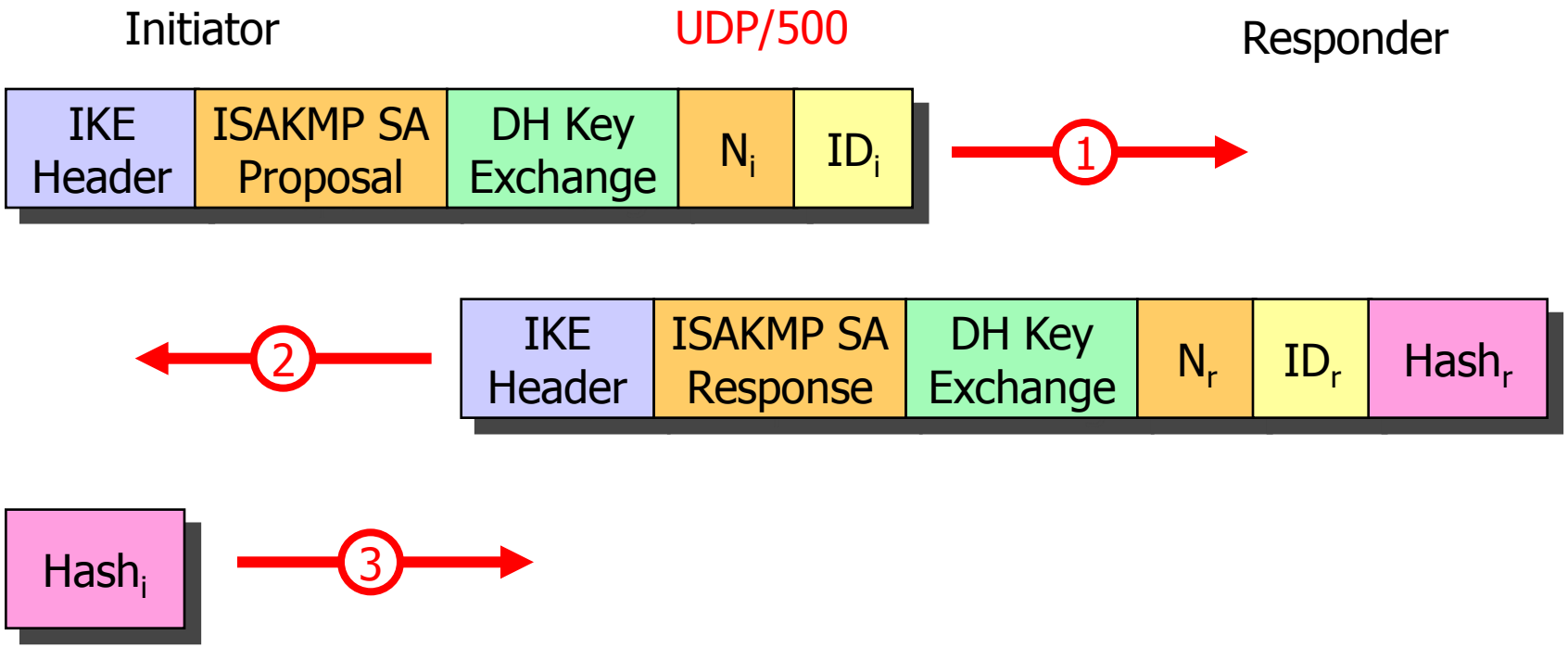

- Unencrypted IKE Aggressive Mode messages carrying cleartext IDs can be easily sniffed by a passive attacker.
- Pre-Shared Key is worked into $Hash_r$, together with other known parameters, so that an off-line cracking attack becomes possible.

Man-in-the-Middle Attack possible with IKEv1 Aggressive Mode and XAUTH

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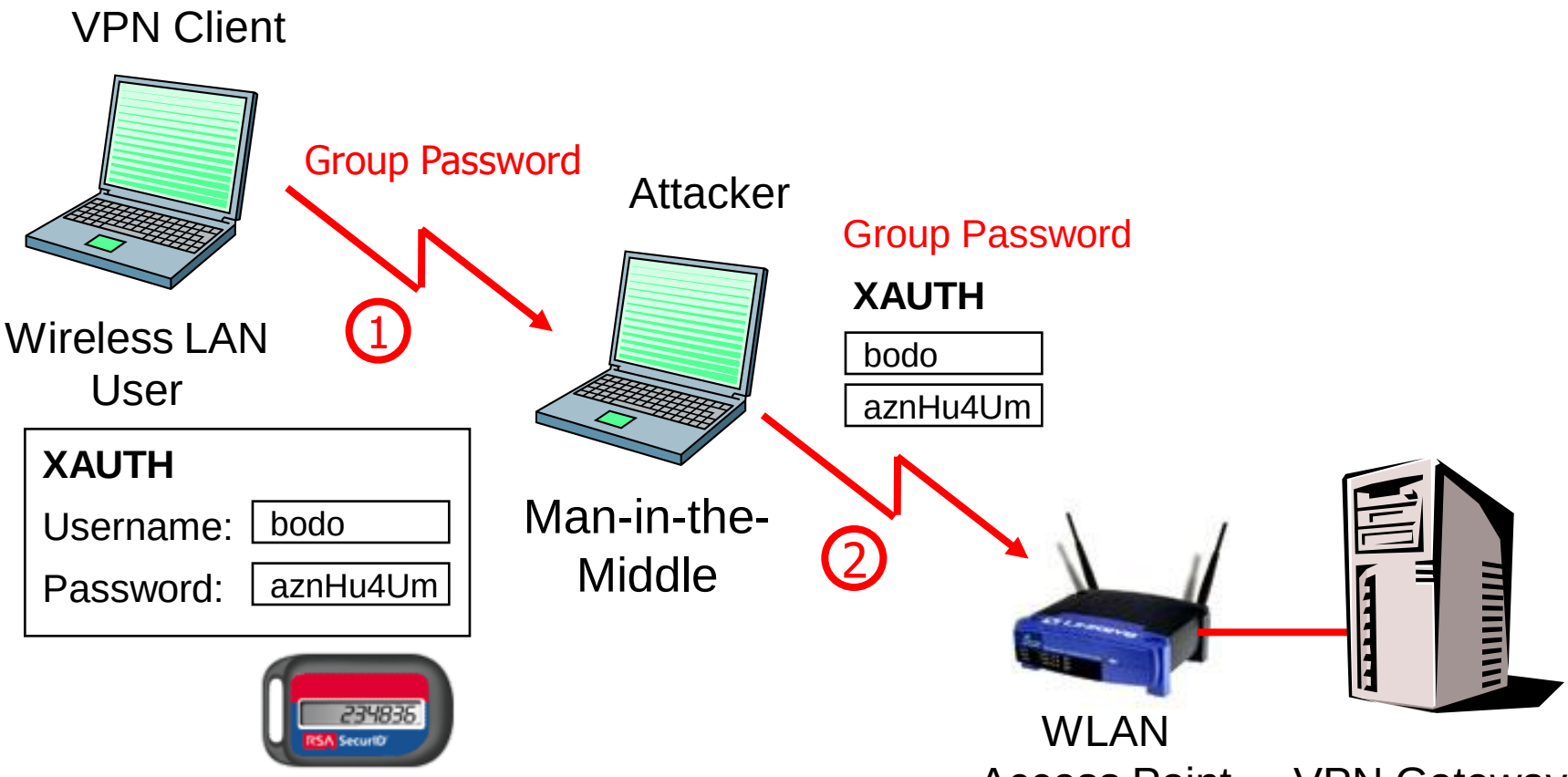

- With IKE Aggressive Mode, use One-Time Password scheme (e.g. SecureID).

IKEv2 Mixed PSK/RSA Authentication

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```
#ipsec.secrets for roadwarrior carol

carol@strongswan.org : PSK "gaga5"
```

```
#ipsec.conf for roadwarrior carol

conn home
      keyexchange=ikev2
      leftauth=psk
      left=%defaultroute
      leftid=carol@strongswan.org
      leftfirewall=yes
      rightauth=pubkey
      right=192.168.0.1
      rightid=@moon.strongswan.org
      rightsubnet=0.0.0.0/0
      auto=start
```

- With weak PSKs vulnerable to MITM dictionary attacks since user sends credentials first!
- Users choose weak passwords!

```
#ipsec.secrets for gateway moon

: RSA moonKey.pem

carol@strongswan.org : \
      PSK „gaga5"

dave@strongswan.org : \
      PSK "jVzONCF02ncsgiSlmIXeqhGN"
```

```
#ipsec.conf for gateway moon

conn rw
      keyexchange=ikev2
      leftauth=pubkey
      left=%any
      leftsubnet=10.1.0.0/16
      leftcert=moonCert.pem
      leftid=@moon.strongswan.org
      leftfirewall=yes
      rightauth=psk
      right=%any
      rightsourceip=10.3.0.0/24
      auto=add
```

IKEv2 EAP Authentication

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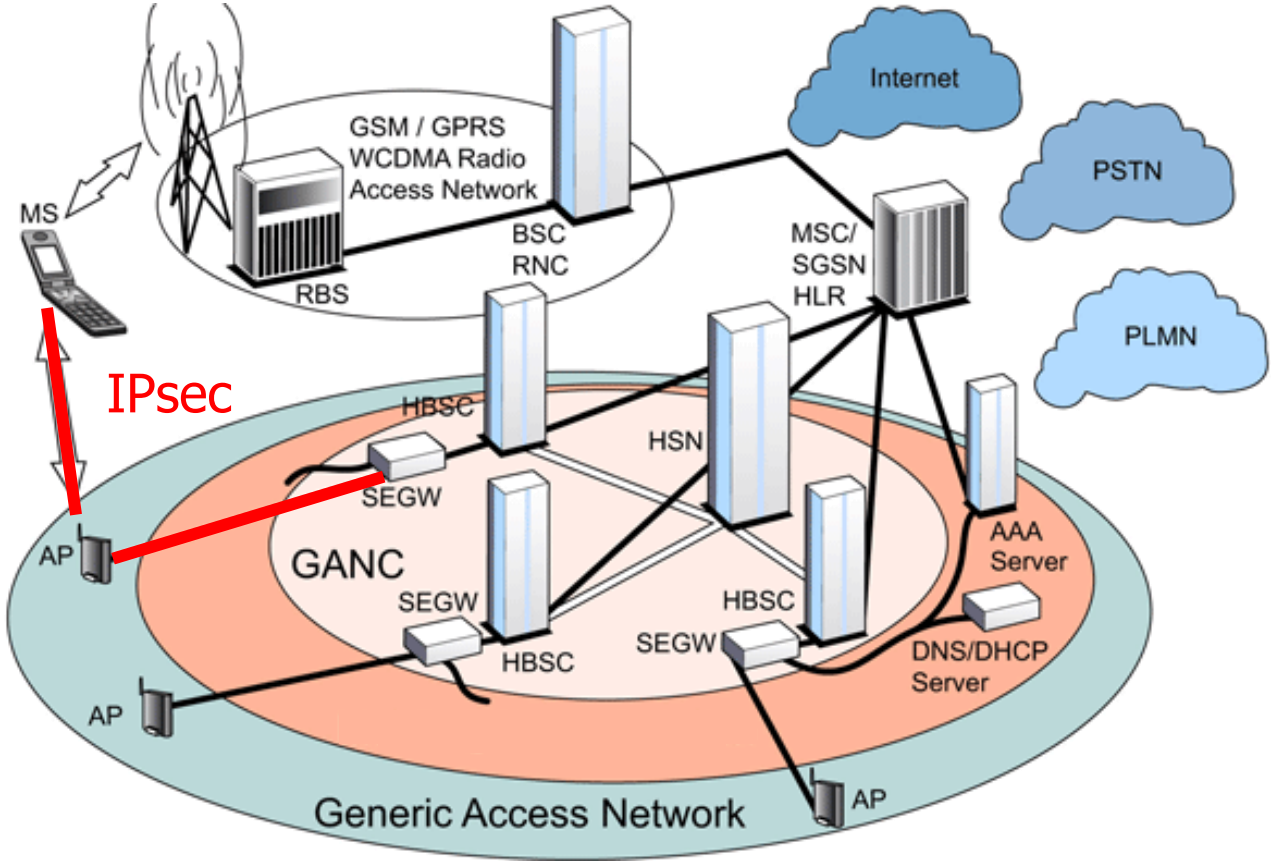

- The 3GPP Generic Access Network (GAN) enables GSM and UMTS services to be delivered over unlicensed WLAN Access Points (APs). Using IKEv2 EAP-SIM or EAP-AKA authentication the Mobile Station (MS) sets up an IPsec tunnel to the GAN Controller (GANC).

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Interoperability with the Windows 7 Agile VPN Client

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Windows 7 VPN with Machine Certificates

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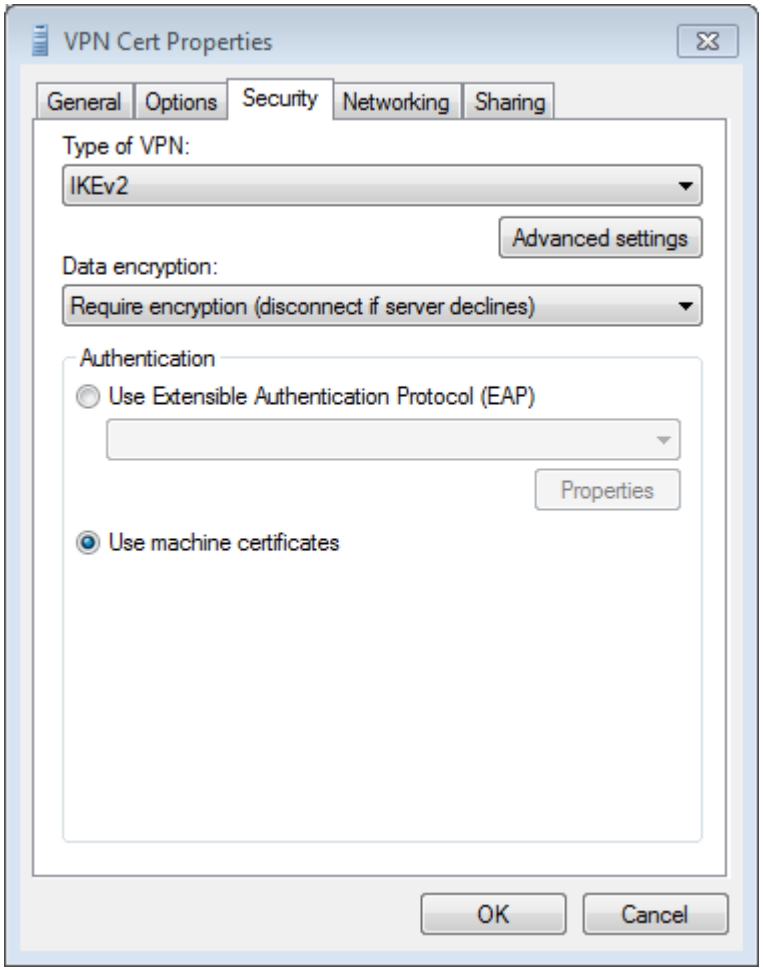

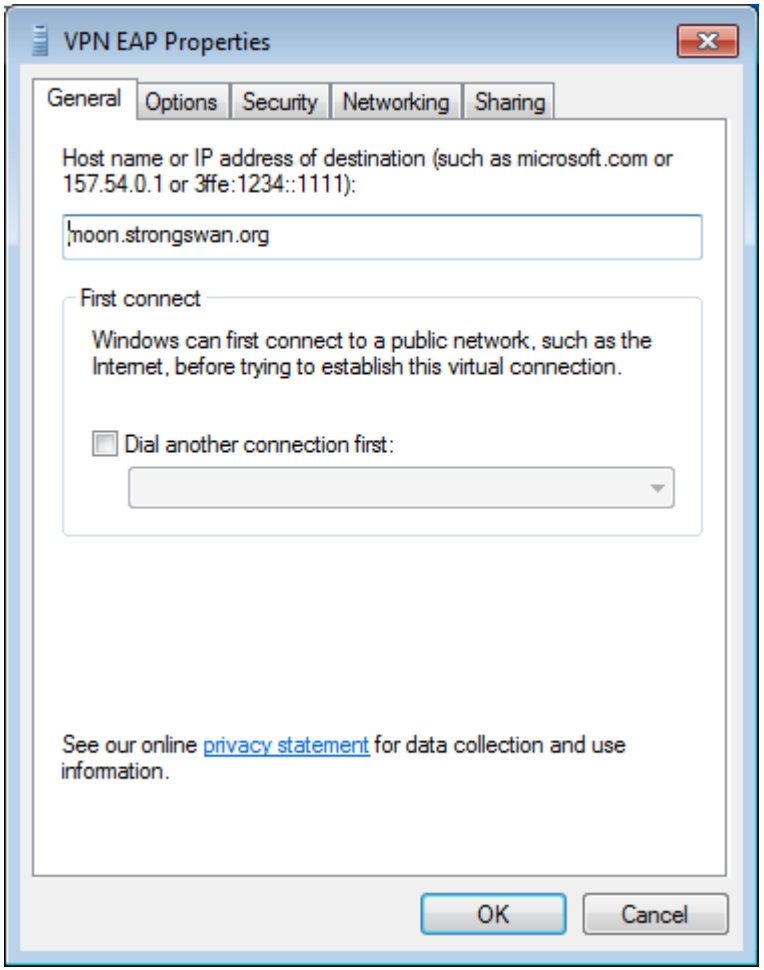

- Gateway certificate must contain host name [or IP address] and the serverAuth extendedKeyUsage flag.

Windows 7 VPN Cert Status

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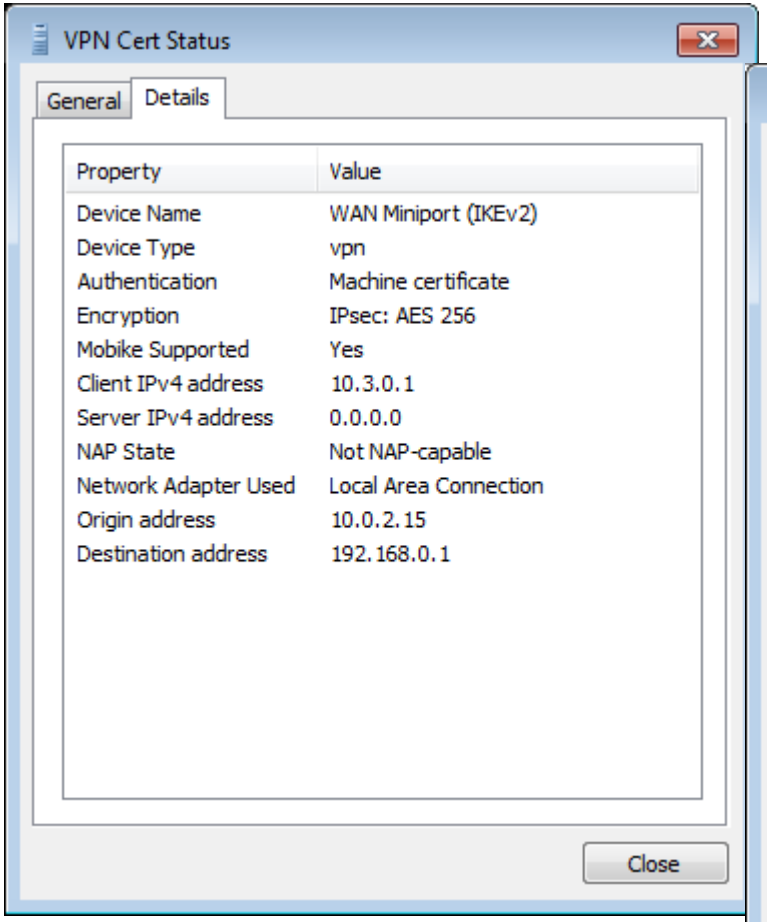

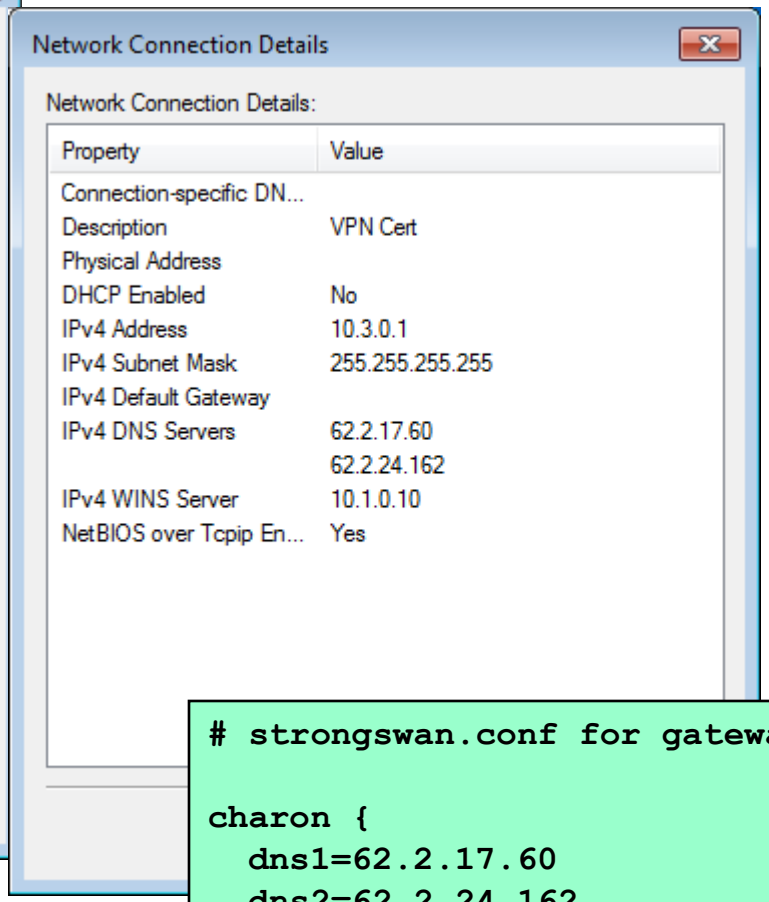


```
# strongswan.conf for gateway moon

charon {
  dns1=62.2.17.60
  dns2=62.2.24.162
  nbns1=10.1.0.10
}
```

Local EAP Credentials Management

Institute for Internet Technologies and Applications

```
# ipsec.secrets for gateway moon

: RSA moonKey.pem

carol : EAP "tuxmux"
dave  : EAP "grummel"
```

```
# ipsec.conf for gateway moon

conn rw
     keyexchange=ikev2
     ike=aes128-aes256-sha256-sha1-modp2048-modp1024!
     esp=aes128-aes256-sha1!
     left=192.168.0.1
     leftsubnet=10.1.0.0/16
     leftcert=moonCert.pem
     leftid=@moon.strongswan.org
     leftauth=pubkey
     leftfirewall=yes
     right=%any
     rightsendcert=never
     rightsourceip=10.3.0.0/24
     rightauth=eap-mschapv2
     eap_identity=%any
     auto=add
```

Windows 7 VPN with EAP Authentication

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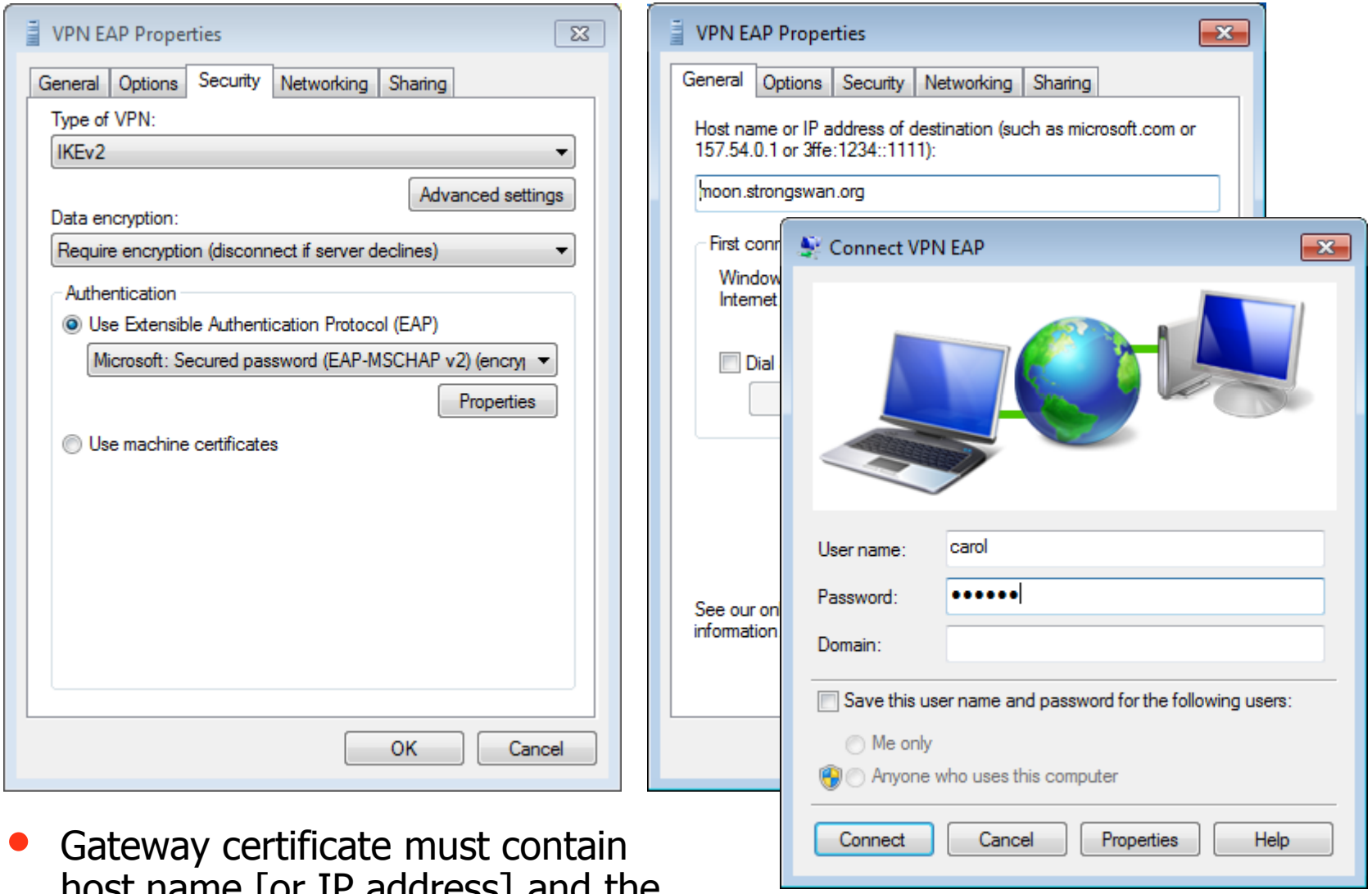

- Gateway certificate must contain host name [or IP address] and the serverAuth extendedKeyUsage flag.

Windows 7 VPN EAP Status

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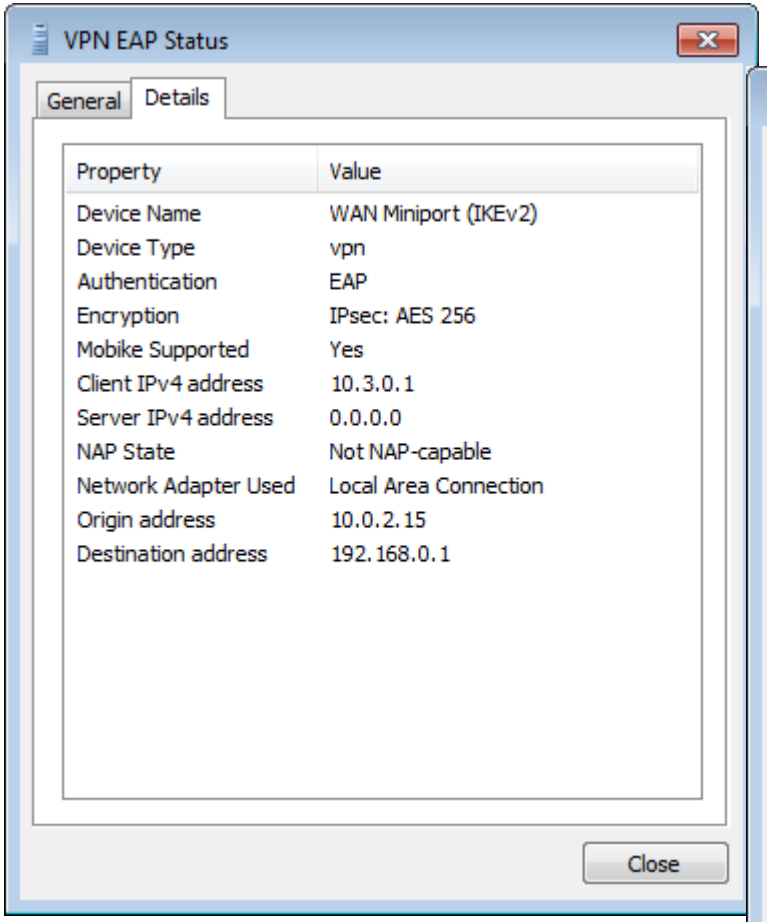

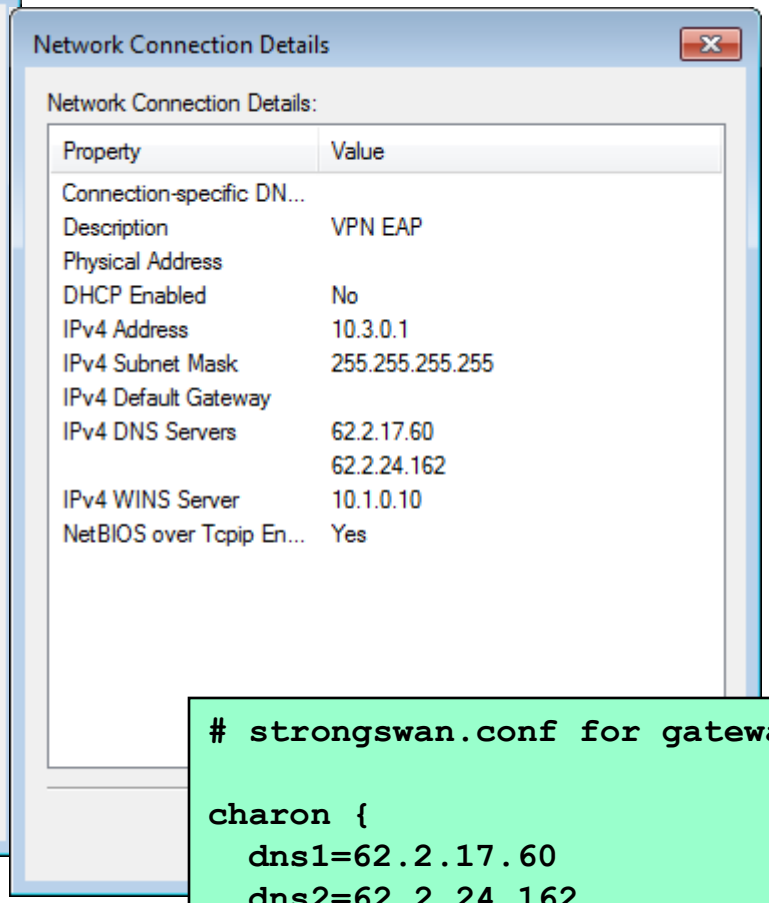


```
# strongswan.conf for gateway moon

charon {
  dns1=62.2.17.60
  dns2=62.2.24.162
  nbns1=10.1.0.10
}
```

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The strongSwan NetworkManager Plugin

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strongSwan NetworkManager VPN Plugin

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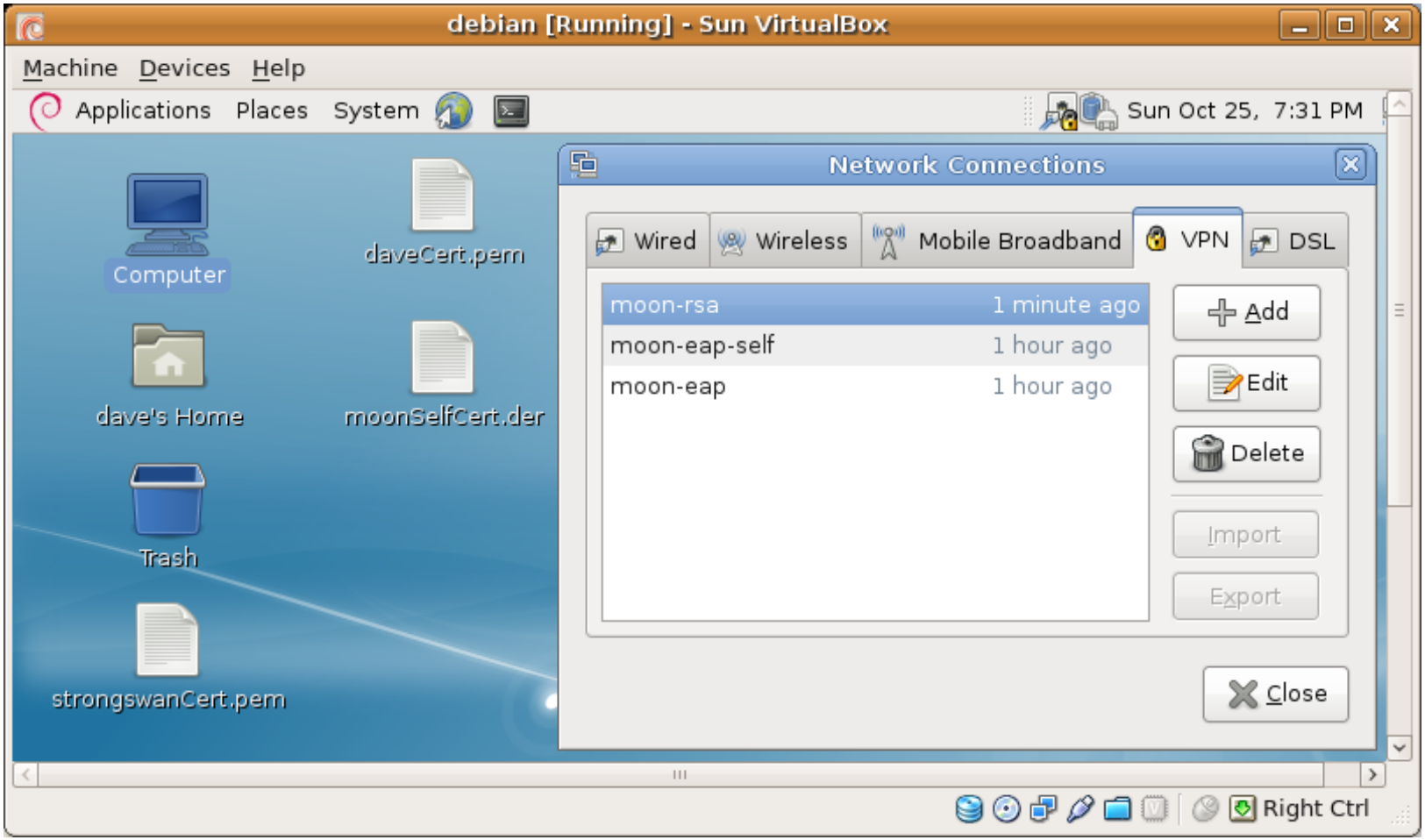

- User authentication: RSA, EAP-GTC, EAP-MSCHAPv2, EAP-...
- Server authentication: Self-Signed Certificate or CA Certificate

strongSwan NetworkManager with EAP I

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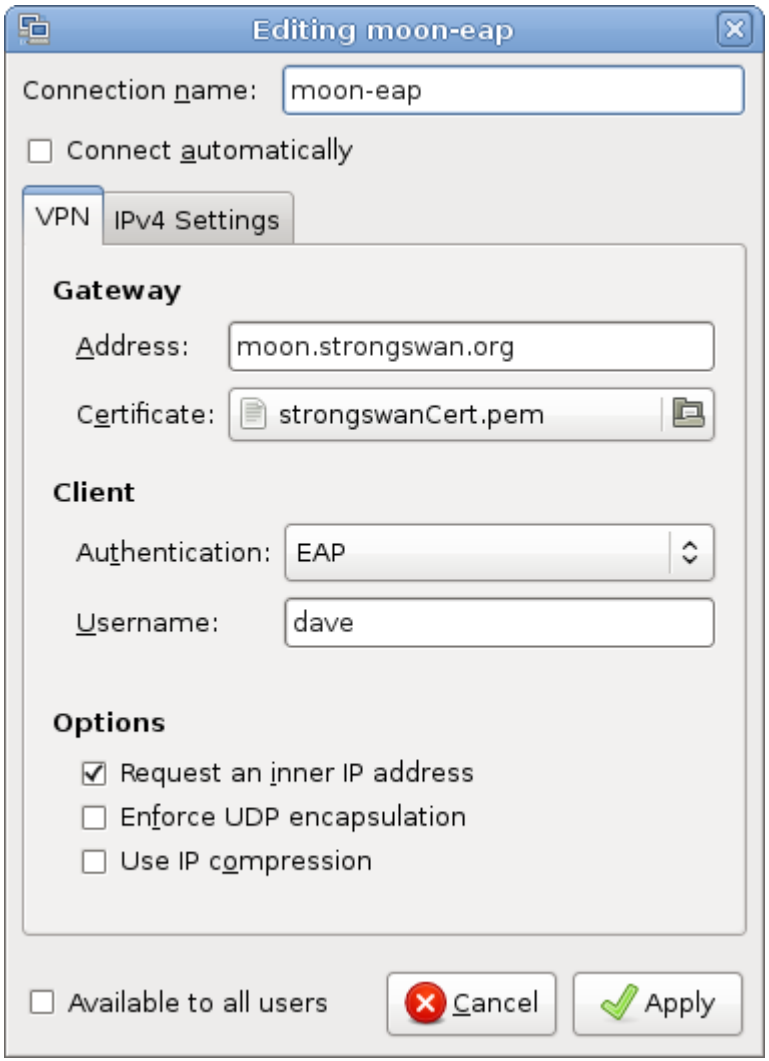

- If a CA root certificate is specified then the hostname [or IP address] of the VPN gateway must be contained as a subjectAltName in the received gateway certificate.

strongSwan NetworkManager with EAP II

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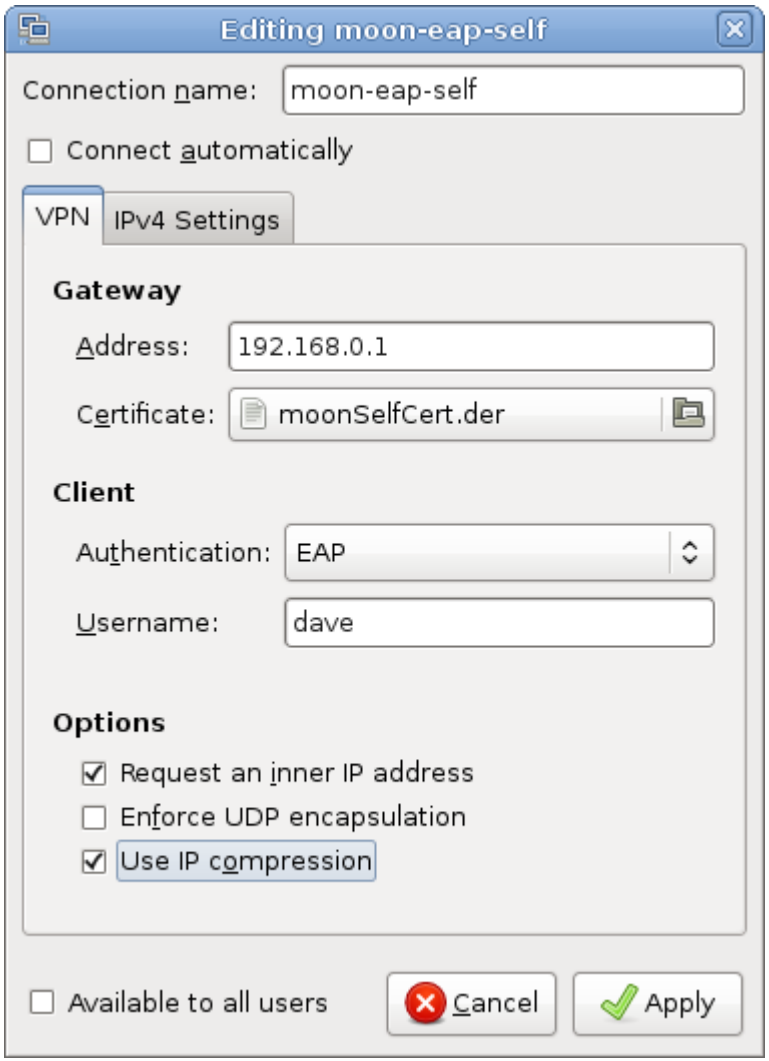

- As an alternative the self-signed certificate of the VPN gateway can be directly imported.

strongSwan NetworkManager with RSA

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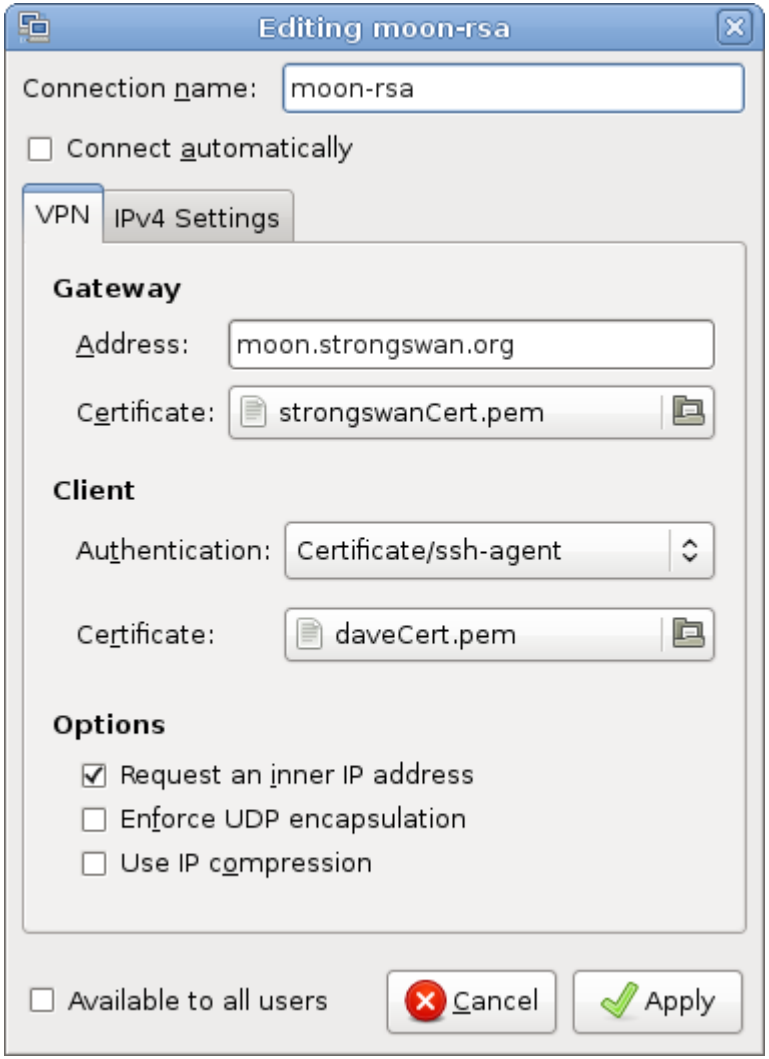

- The private RSA key stored in .ssh/id_rsa in PKCS#1 PEM format is managed by the ssh-agent and can be directly by strongSwan via the agent plugin.

Connection status on gateway moon

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```
Virtual IP pools (size/online/offline):
  rw: 255/2/0
Listening IP addresses:
 Connections:
  rw:  192.168.0.1...%any
  rw:   local:  [moon.strongswan.org] uses public key authentication
  rw:    cert:  "C=CH, O=Linux strongSwan, CN=moon.strongswan.org"
  rw:   remote: [%any] uses EAP_MSCHAPV2 authentication with EAP identity '%any'
  rw:   child:  10.1.0.0/16 === dynamic
Security Associations:
  rw[1]: ESTABLISHED 5 minutes ago, 192.168.0.1[moon.strongswan.org]...
                                          192.168.0.254[10.0.2.15]
  rw[1]: IKE SPIs: 6d64603959c40c35_i cedb9920fa698283_r*,
  rw[1]: IKE proposal: AES_CBC_256/HMAC_SHA1_96/PRF_HMAC_SHA1/MODP_1024
  rw{1}:  INSTALLED, TUNNEL, ESP in UDP SPIs: c07e2ac6_i 2566d5f3_o
  rw{1}:  AES_CBC_256/HMAC_SHA1_96, 480 bytes_i (53s ago), 480 bytes_o (53s ago)
  rw{1}:   10.1.0.0/16 === 10.3.0.1/32
  rw[3]: ESTABLISHED 20 seconds ago, 192.168.0.1[moon.strongswan.org]...
                                           192.168.0.254[dave]
  rw[3]: IKE SPIs: d090764d9d84fa0e_i f80f74f0e109e453_r*,
  rw[3]: IKE proposal: AES_CBC_128/HMAC_SHA2_256_128/PRF_HMAC_SHA2_256/MODP_2048
  rw{2}:  INSTALLED, TUNNEL, ESP in UDP SPIs: c73ddbf5_i c60375cc_o
  rw{2}:  AES_CBC_128/HMAC_SHA1_96, 840 bytes_i (1s ago), 840 bytes_o (1s ago),
  rw{2}:   10.1.0.0/16 === 10.3.0.2/32
```

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EAP-Radius based Authentication

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RADIUS Server Configuration

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moon

```
# strongswan.conf of gateway moon

charon {
  plugins {
    eap-radius {
      secret = gv6URkSs
      server = 10.1.0.10
    }
  }
}
```

```
# ipsec.conf of gateway moon

conn rw-eap
    left=192.168.0.1
    leftsubnet=10.1.0.0/16
    leftid=@moon.strongswan.org
    leftcert=moonCert.pem
    leftauth=pubkey
    leftfirewall=yes
    right=%any
    rightsendcert=never
    rightsourceip=10.3.0.0/24
    rightauth=eap-radius
    eap_identity=%any
    auto=add
```

radius server

```
# /etc/raddb/clients.conf

client 10.1.0.1 {
  secret    = gv6URkSs
  shortname = moon
```

```
# /etc/raddb/eap.conf

eap {
  default_eap_type = md5
  md5 {
  }
}
```

```
# /etc/raddb/proxy.conf

realm LOCAL {
  type     = radius
  authhost = LOCAL
  accthost = LOCAL
}
```

```
# /etc/raddb/users

carol    Cleartext-Password := "tuxmux"
dave     Cleartext-Password := "grummel"
```

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strongSwan Software Architecture

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IKEv2 Daemon – Software Architecture

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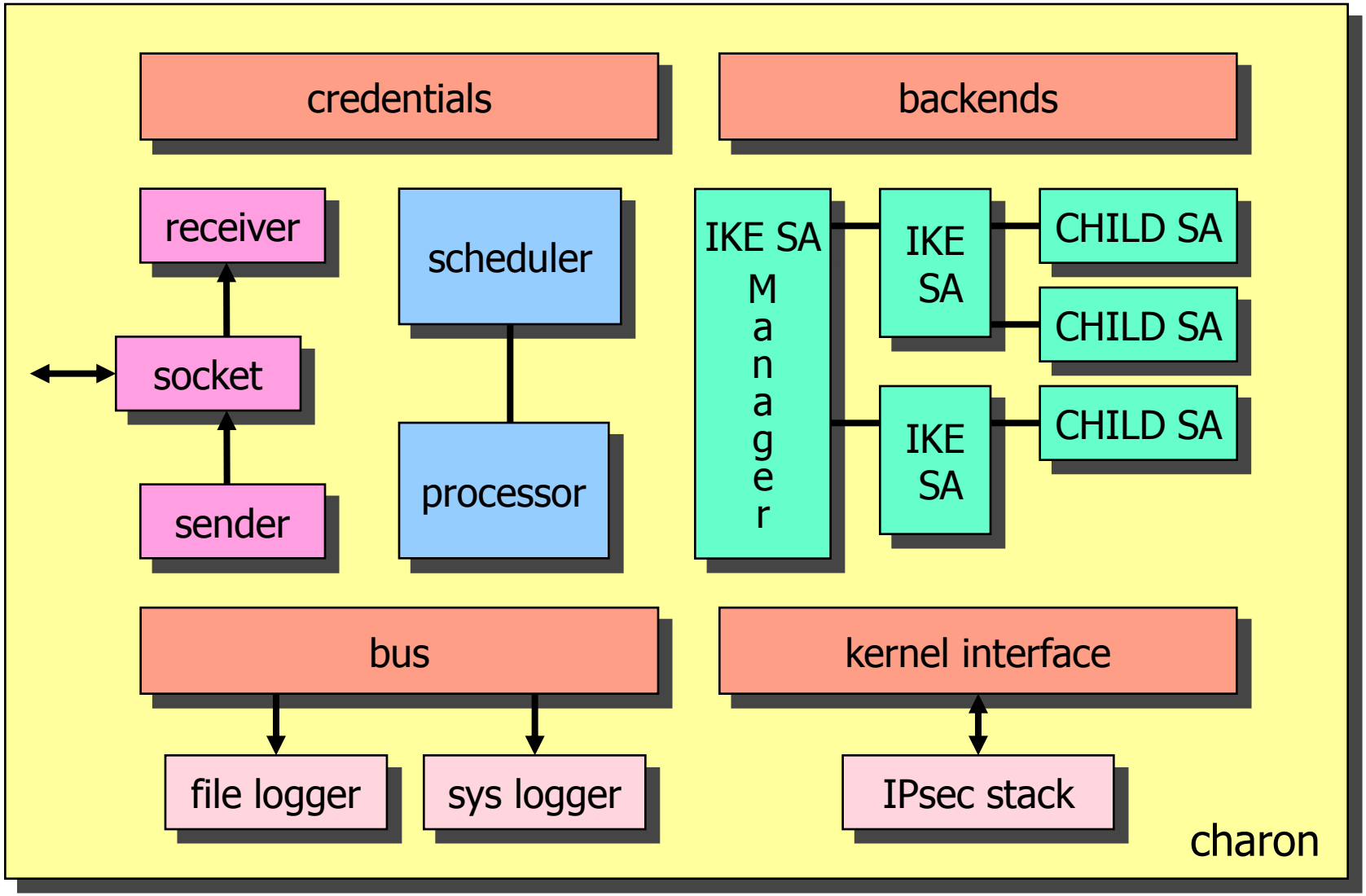

16 concurrent worker threads

Plugins for charon

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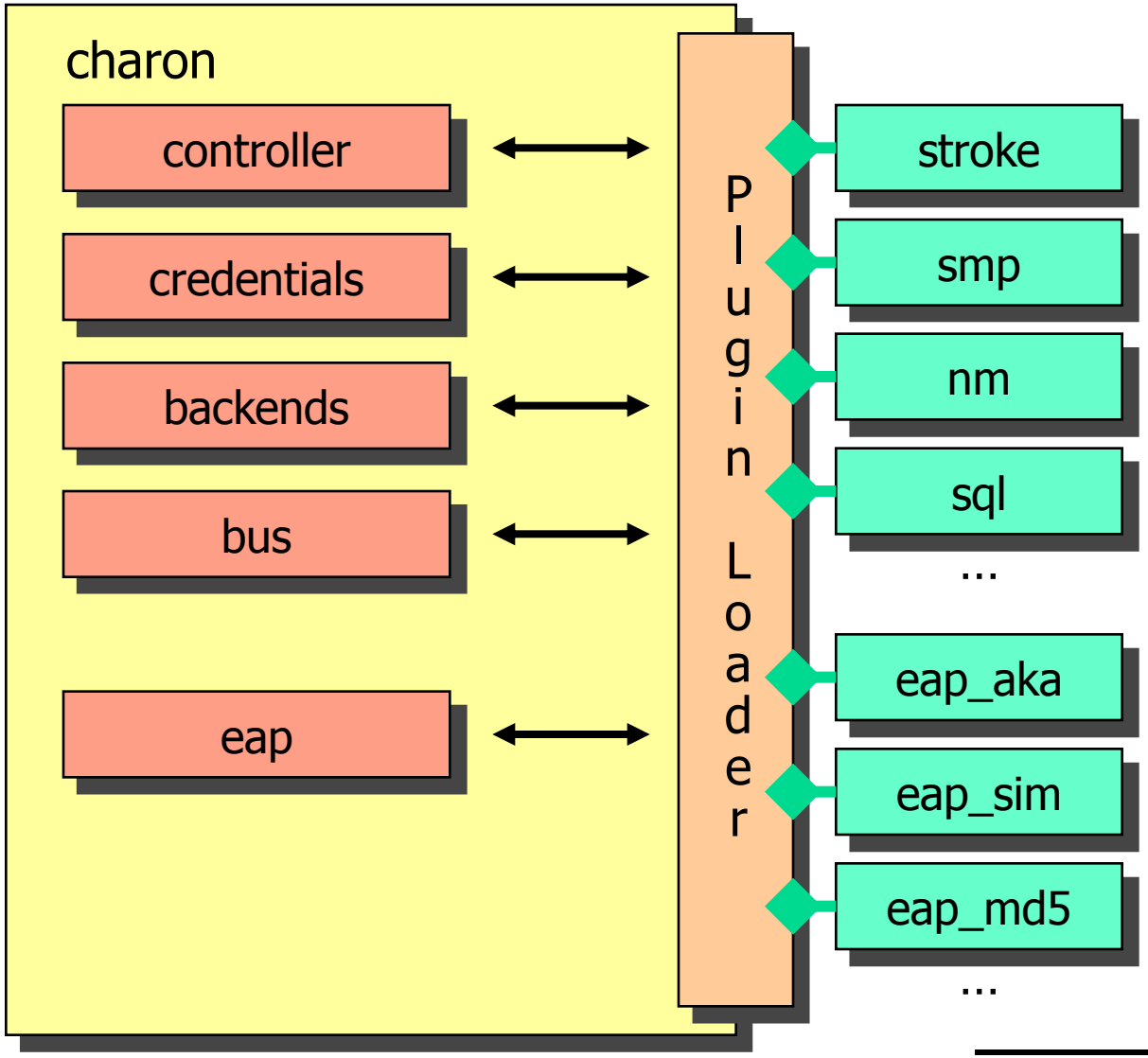

- smp
  XML-based control and management protocol.
  Implementation: strongSwan Manager
- nm
  DBUS-based plugin for NetworkManager
- sql
  Generic SQL interface for configurations, credentials & logging.
  Implementations: SQLite & MySQL
- eap_x
  Any EAP protocol.

strongSwan Manager

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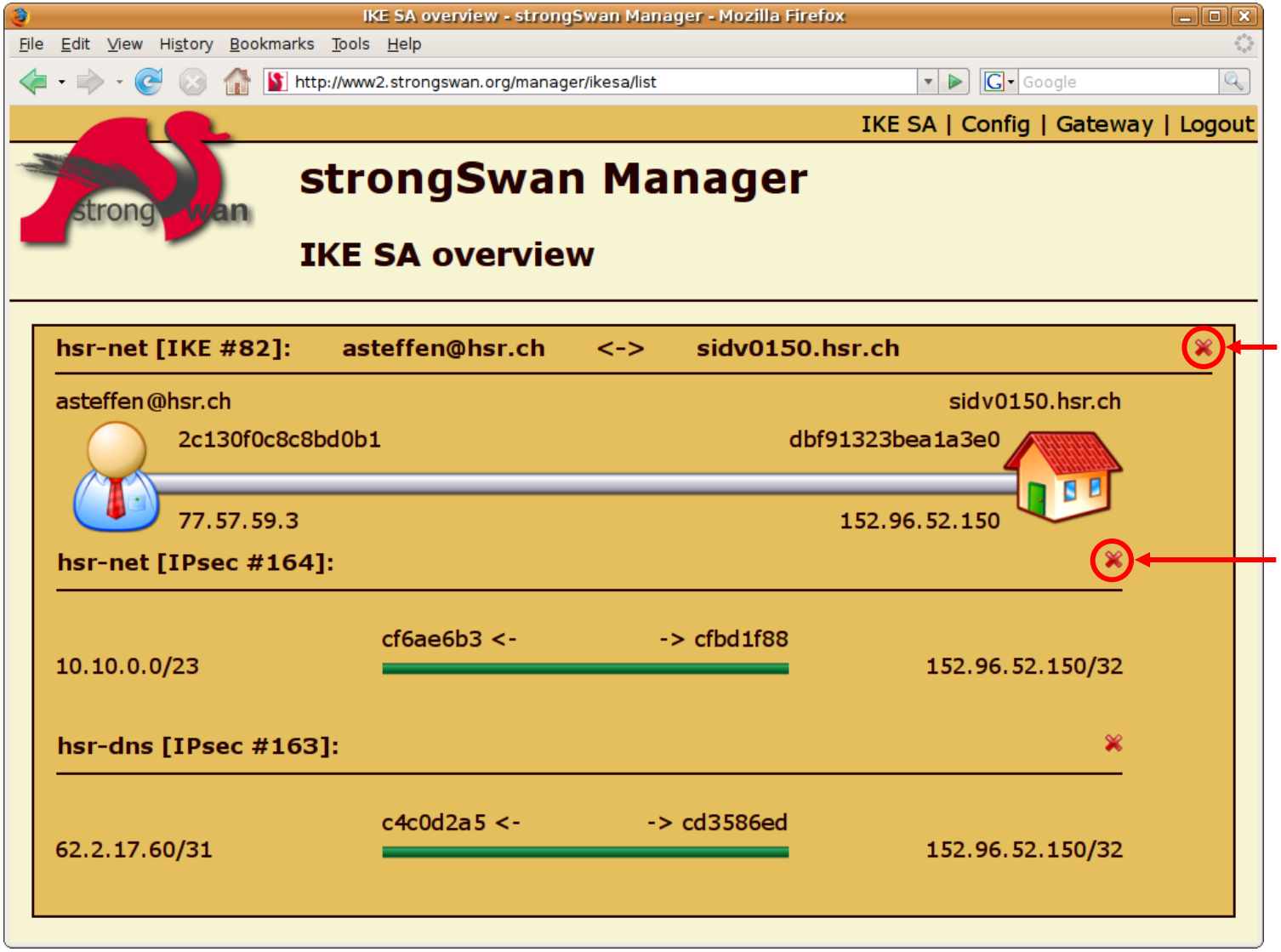

take down IKE SA

take down IPsec SA

FastCGI written in C with ClearSilver templates

strongSwan Entity Relationship Diagram

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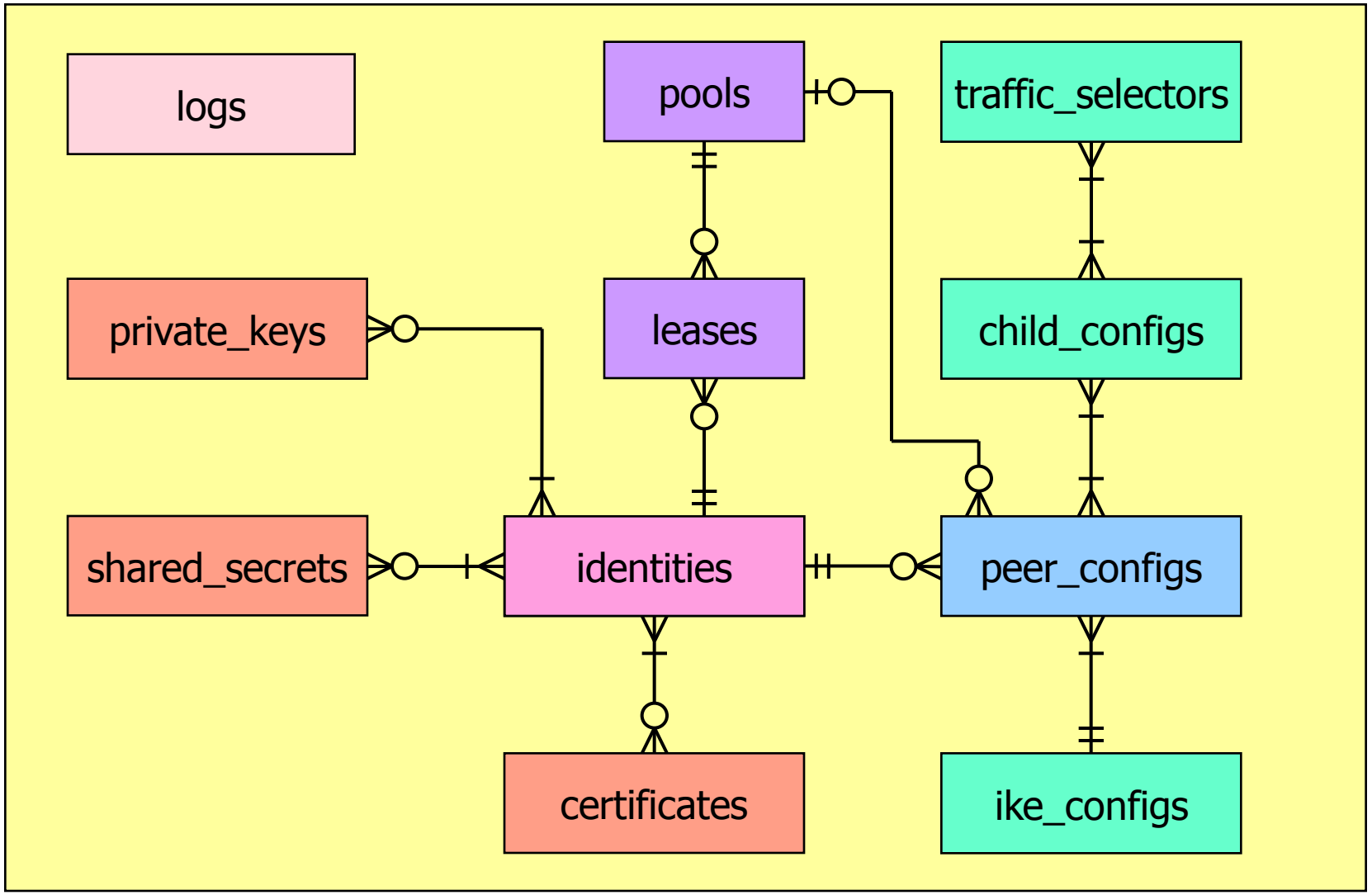

SQLite and MySQL implementations

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Cryptographic Plugins

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Plugins for libstrongswan

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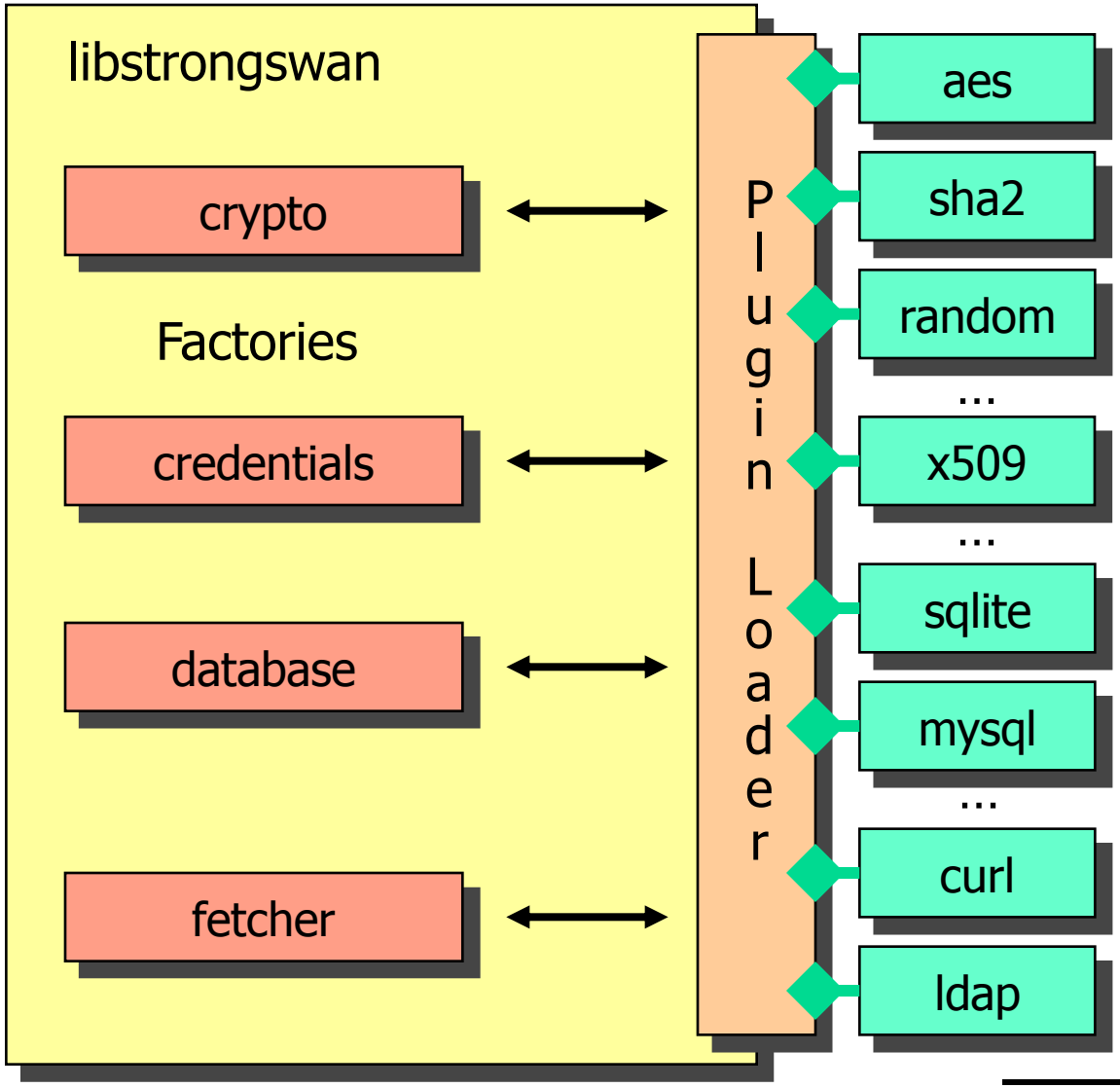

- Non-US crypto code
- No OpenSSL library
- ECCN: No License Required (NLR)

- Certificate retrieval (HASH-and-URL)
- CRL fetching, OCSP

VIA EPIA-NX PadLock Crypto-Processor

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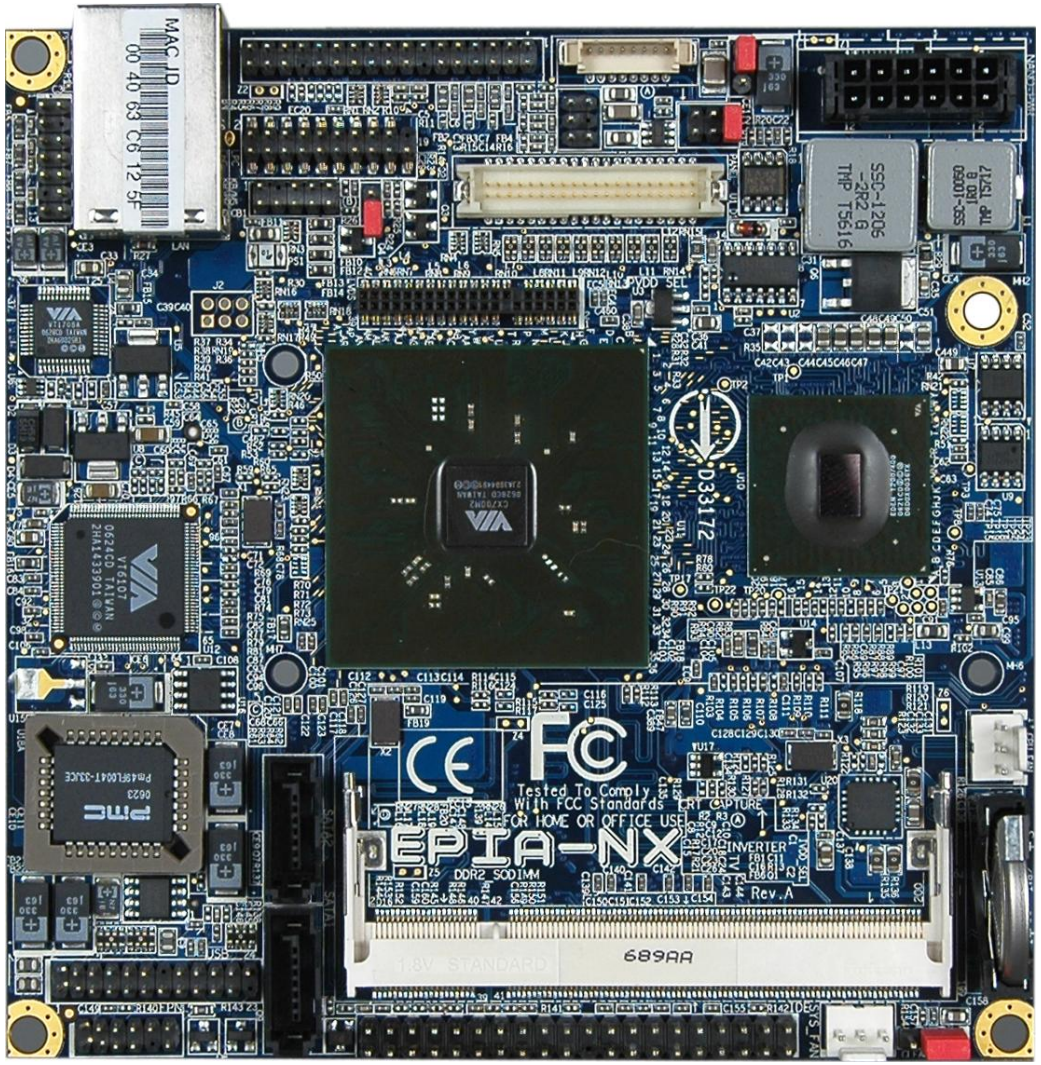
- padlock plugin
  AES/SHA
  HW acceleration
- openssl plugin
  uses libcrypto-0.9.8 OpenSSL library
  - ECP DH groups
  - ECDSA signatures
  - HW engine support



The strongSwan PKI function

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```
ipsec pki --gen  --type ecdsa --size 521 > strongswanKey.der
ipsec pki --self --in strongswanKey.der -type ecdsa --lifetime 3650
                 --dn "C=CH, O=strongSwan, CN=strongSwan EC CA"
                 --ca --digest sha512 > strongswanCert.der

ipsec pki --gen  --type ecdsa --size 384 > moonKey.der
ipsec pki --req  --in moonKey.der --type ecdsa --digest sha384
                 --dn "C=CH, O=strongSwan, CN=moon.strongswan.org"
                 --san moon.strongswan.org > moonReq.der

ipsec pki --gen  --type ecdsa --size 256 > carolKey.der
ipsec pki --req  --in carolKey.der --type ecdsa --digest sha256
                 --dn "C=CH, O=strongSwan, CN=carol@strongswan.org"
                 --san carol@strongswan.org > carolReq.der

cat pki.opt
--type pkcs10 --lifetime 1825  --crl http://crl.strongswan.org/ecdsa.crl
--cacert strongswanCert.der --cakey strongswanKey.der --digest sha512

ipsec pki --issue --options pki.opt --in moonReq.der --flag serverAuth
                                    --serial 01 > moonCert.der
ipsec pki --issue --options pki.opt --in carolReq.der
                                    --serial 02 > carolCert.der
```

Suite B offers constant 128/192 Bit Security

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```
# ipsec.secrets for gateway moon
: ECDSA moonKey.der
```

```
# ipsec.conf for gateway moon
conn rw
     keyexchange=ikev2
     ike=aes256-sha384-ecp384,aes128-sha256-ecp256!
     esp=aes256gcm16,aes128gcm16!
     leftsubnet=10.1.0.0/24
     leftcert=moonCert.der
     leftid=@moon.strongswan.org
     right=%any
     rightsourceip=10.3.0.0/24
     auto=add
```

- 128 bit security requires 3072 bit RSA keys and DH groups!
- In 2005 NSA proposes use of efficient elliptic curve cryptography.
- Suite B use for IPsec defined in RFC 4869.

```
rw[1]: ESTABLISHED 9 seconds ago, 192.168.0.1[moon.strongswan.org]...
                                  192.168.0.100[carol@strongswan.org]
rw[1]: IKE SPIs: 7c1dcd22a8266a3b_i 12bc51bc21994cdc_r*,
rw[1]: IKE proposal: AES_CBC_128/HMAC_SHA2_256_128/PRF_HMAC_SHA2_256/ECP_256
rw{1}:  INSTALLED, TUNNEL, ESP SPIs: c05d34cd_i c9f09b38_o
rw{1}:  AES_GCM_16_128, 84 bytes_i (6s ago), 84 bytes_o (6s ago),
rw{1}:   10.1.0.0/24 === 10.3.0.1/32
```

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High Availability using Cluster IP

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strongswan

strongSwan High-Availability Architecture

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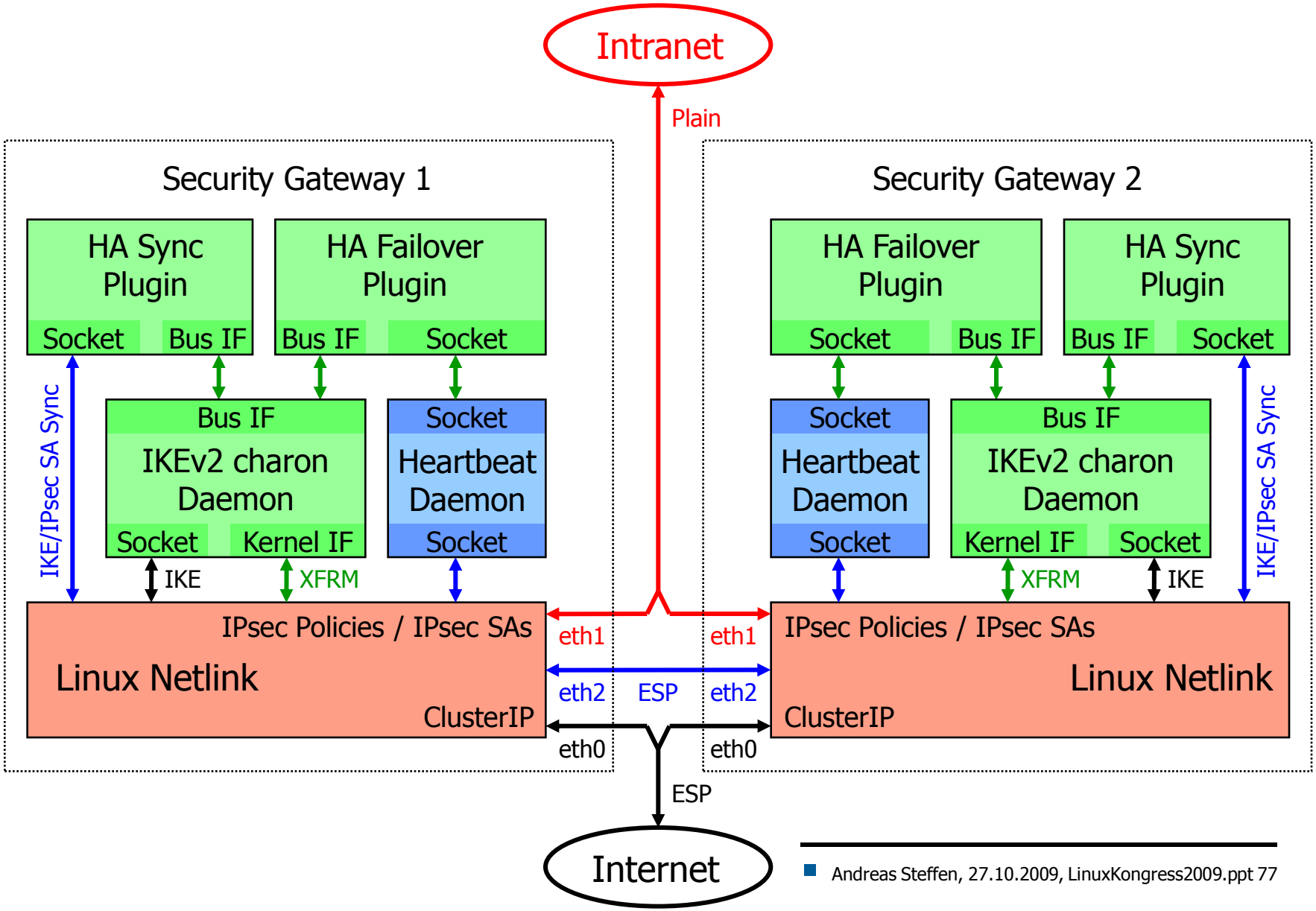

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IKEv2 Mediation Extension

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Peer-to-Peer NAT-Traversal for IPsec

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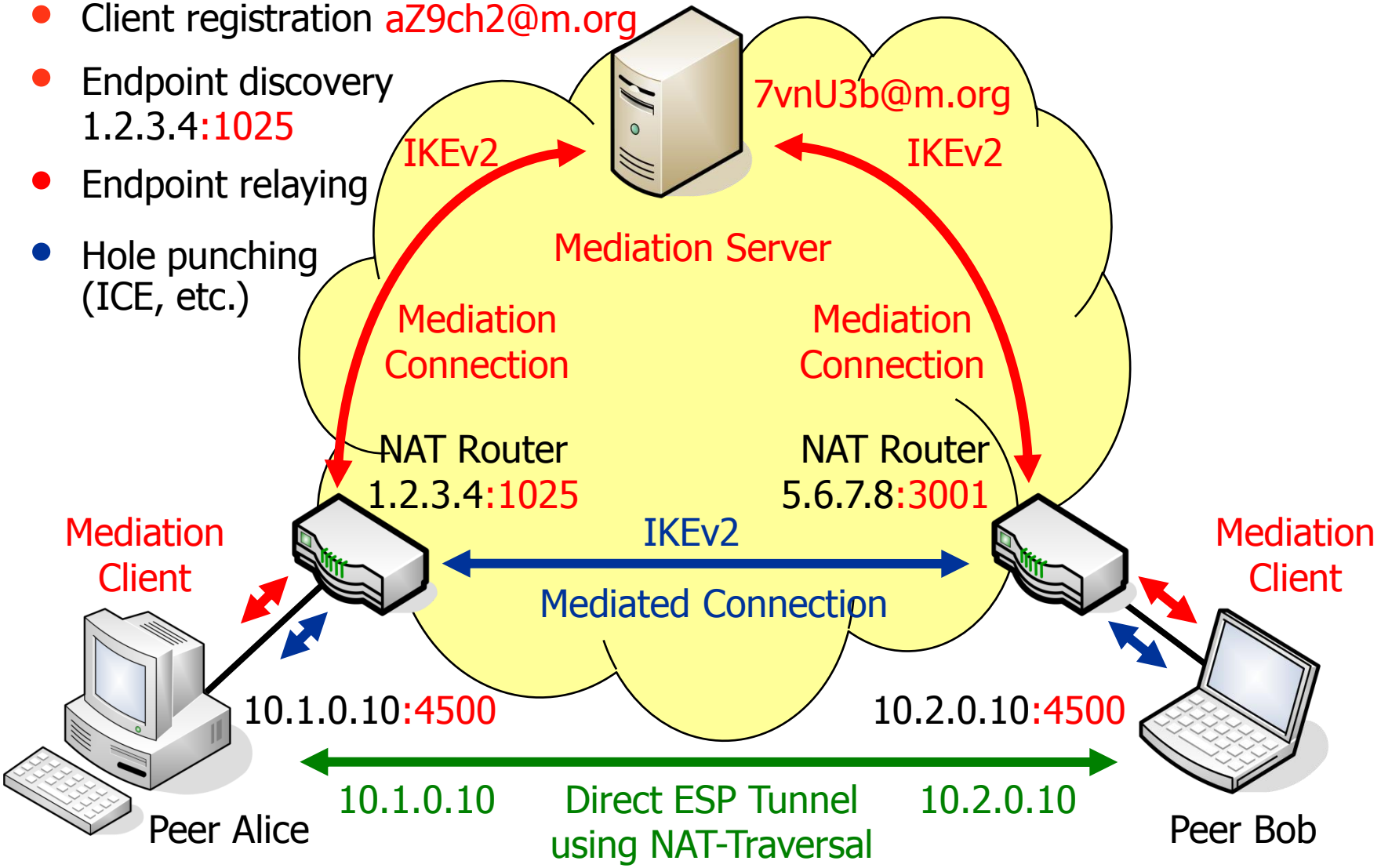
- Client registration aZ9ch2@m.org
- Endpoint discovery 1.2.3.4:1025
- Endpoint relaying
- Hole punching (ICE, etc.)



draft-brunner-ikev2-mediation released

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Login at the strongSwan Mediation Manager

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Register a Peer with the Mediation Manager

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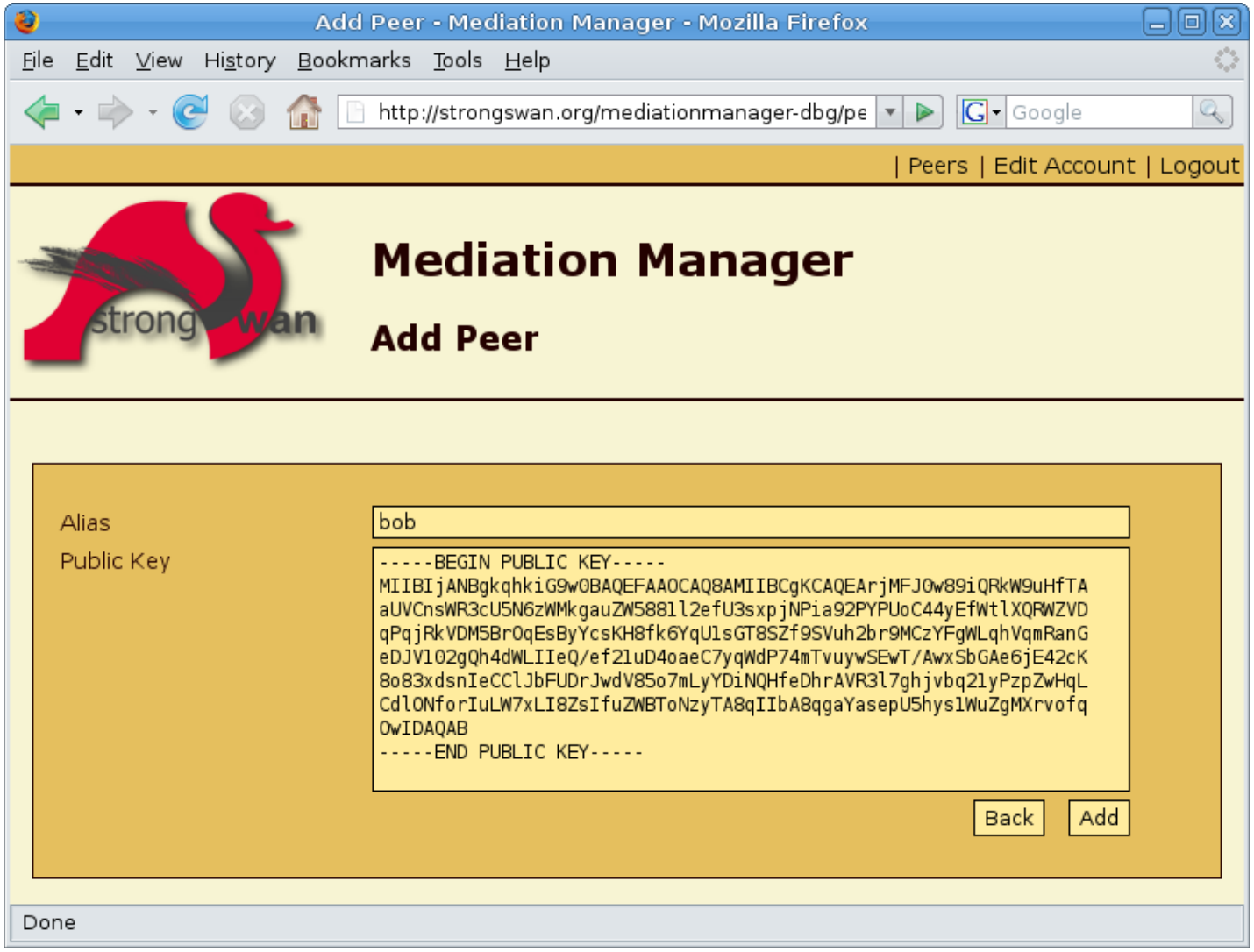

List of Registered Peers

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