IKEv2 with CGA

Jean-Michel Combes

jeanmichel.combes@orange.com

Aurélien Wailly

aurelien.wailly@orange.com

Maryline Laurent

Maryline.Laurent@it-sudparis.eu

Outline

- IPsec
- IKEv2
- CGA
- IKEv2 with CGA?
- IKEv2 exchanges
- IPsec/IKEv2 modifications
- Implementation
- IKEv2+CGA improvements
- Conclusion

Outline

- **IPsec**
- IKEv2
- CGA
- IKEv2 with CGA?
- IKEv2 exchanges
- IPsec/IKEv2 modifications
- Implementation
- IKEv2+CGA improvements
- Conclusion

IPsec (1/2)

- IPsec [RFC4301]
  - IP security
  - Authentication Header (AH) for authentication
  - Encapsulating Security Payload (ESP) for authentication/encryption
  - 2 modes
    - Transport
    - Tunnel (e.g., "VPN" is ESP/Tunnel)

IPsec (2/2)

- 3 databases
  - Security Policy Database (SPD)
    - Allow/Discard/IPsec policy for a specific IP flow
  - Security Association Database (SAD)
    - Configuration of an IPsec connection
  - Peer Authorization Database (PAD)
    - Configuration of the security material used by an IPsec peer

Outline

- IPsec
- **IKEv2**
- CGA
- IKEv2 with CGA?
- IKEv2 exchanges
- IPsec/IKEv2 modifications
- Implementation
- IKEv2+CGA improvements
- Conclusion

IKEv2

- Internet Key Exchange version 2 (IKEv2) [RFC5996]
  - To configure SAD dynamically
  - Use SPD and PAD
  - Security material
    - pre-shared keys
    - X.509 certificates
    - Extensible Authentication Protocol (EAP), not mandatory

Outline

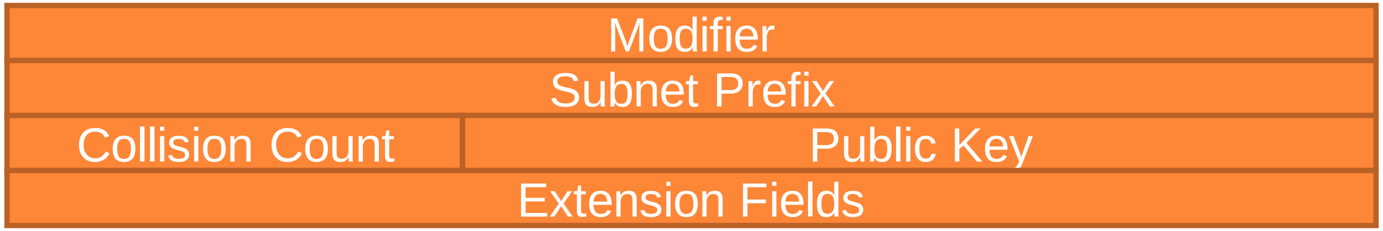
- IPsec
- IKEv2
- **CGA**
- IKEv2 with CGA?
- IKEv2 exchanges
- IPsec/IKEv2 modifications
- Implementation
- IKEv2+CGA improvements
- Conclusion

CGA (1/3)

- Cryptographically Generated Addresses (CGA) [RFC3972]
  - IPv6 addresses resulting from the hash of parameters
  - Used with Secure Neighbor Discovery (SEND) [RFC3971]
    - Neighbor Discovery "equivalent" to ARP for IPv6
    - SEND, security for Neighbor Discovery

CGA (2/3)

- IPv6 address
  - – Subnet Prefix (64 bits) || Interface ID (64 bits)
- Public/private key pair
- CGA Parameters



Modifier

Subnet Prefix

Collision Count | Public Key

Extension Fields

- Interface ID = First64(Hash(CGA Parameters))

CGA (3/3)

- CGA ownership checking
  - Step 1: regeneration of the CGA, based on received CGA Parameters
  - Step 2: validity of data signed with the CGA private key associated to the public one

Outline

- IPsec
- IKEv2
- CGA
- **IKEv2 with CGA?**
- IKEv2 exchanges
- IPsec/IKEv2 modifications
- Implementation
- IKEv2+CGA improvements
- Conclusion

IKv2 with CGA? (1/4)

- EAP
  - not mandatory in IKEv2 implementations
- Pre-shared keys
  - complex provision
  - not scalable
- X.509 certificates
  - require a Public Key Infrastructure (PKI)
    - associated costs
    - introduction of potential vulnerabilities

IKEv2 with CGA? (2/4)

- CGA, an alternative security material for IKEv2?
  - Based on an academic paper [CMLN04] and an IETF draft [LMK07]

IKEv2 with CGA? (3/4)

- Advantages
  - No need of a PKI
  - Self-generated by the owner
  - All the needed material to check a CGA sent directly to the receiver

IKEv2 with CGA? (4/4)

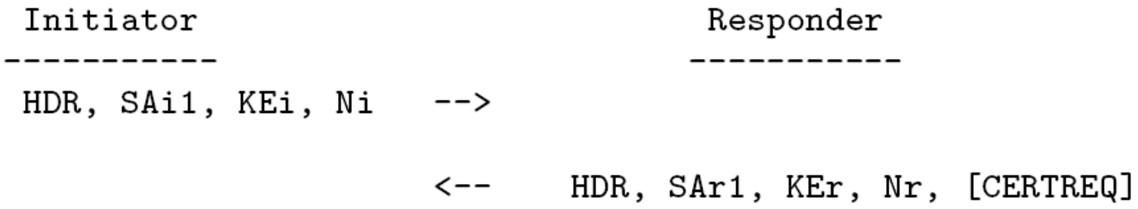
- Drawbacks
  - Identity
    - CGA, hard to remember for a human
    - Need to be associated to a Fully Qualified Domain Name (FQDN) stored in Domain Name Server (DNS)
  - "Hard-coded" cryptographic algorithms
    - SHA-1 mandatory
    - RSA (minimum key length is 384 bits)
  - No revocation

Outline

- IPsec
- IKEv2
- CGA
- IKEv2 with CGA?
- **IKEv2 exchanges**
- IPsec/IKEv2 modifications
- Implementation
- IKEv2+CGA improvements
- Conclusion

IKEv2 exchanges (1/2)

- IKEv2 exchanges
  - IKE_SA_INIT



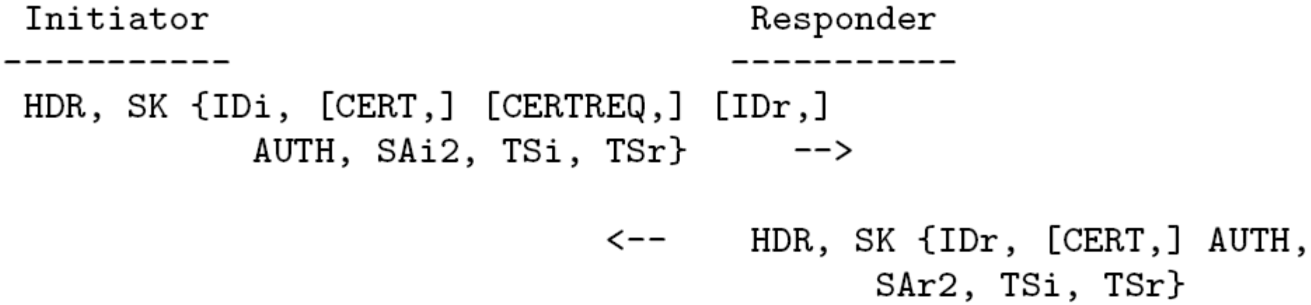
```
 Initiator                          Responder
-----------                        -----------
 HDR, SAi1, KEi, Ni   -->

                      <--    HDR, SAr1, KEr, Nr, [CERTREQ]
```

    - Diffie-Hellman key exchange (KEi, KEr)
    - IKEv2 Security Association (SA) negotiation (SAi1, SAr1)

IKEv2 exchanges (2/2)

- IKE_AUTH



```
 Initiator                         Responder
-----------                       -----------
 HDR, SK {IDi, [CERT,] [CERTREQ,] [IDr,]
           AUTH, SAi2, TSi, TSr}     -->

                                <--    HDR, SK {IDr, [CERT,] AUTH,
                                             SAr2, TSi, TSr}
```

  - Peers identification (IDi, IDr)
  - Peers' security material exchange (CERTREQ, CERT)
  - Peers authentication (AUTH)
  - IPsec SA negotiation (SAi2, SAr2, TSi, TSr)

Outline

- IPsec
- IKEv2
- CGA
- IKEv2 with CGA?
- IKEv2 exchanges
- **IPsec/IKEv2 modifications**
- Implementation
- IKEv2+CGA improvements
- Conclusion

IPsec/IKEv2 modifications (1/3)

- IPsec
  - Peer Authorization Database (PAD)
    - Peer identity (ID_IPV6_ADDR) associated with CGA authentication method
- IKEv2
  - IDi, IDr
    - ID_IPV6_ADDR == CGA

IPsec/IKEv2 modifications (2/3)

- CERT
  - New type: 222
  - Includes CGA parameters
  - Format looks like a self-signed certificate
- CERTREQ
  - New type: 222
- AUTH
  - Signature based on the private key associated to the CGA public one

IPsec/IKEv2 modifications (3/3)

- AUTH validity
  - CGA ownership checking
    - Step 1: regeneration of the CGA, based on received CGA Parameters
    - Step 2: validity of data signed with the CGA private key associated to the public one

Outline

- IPsec
- IKEv2
- CGA
- IKEv2 with CGA?
- IKEv2 exchanges
- IPsec/IKEv2 modifications
- **Implementation**
- IKEv2+CGA improvements
- Conclusion

Implementation (1/3)

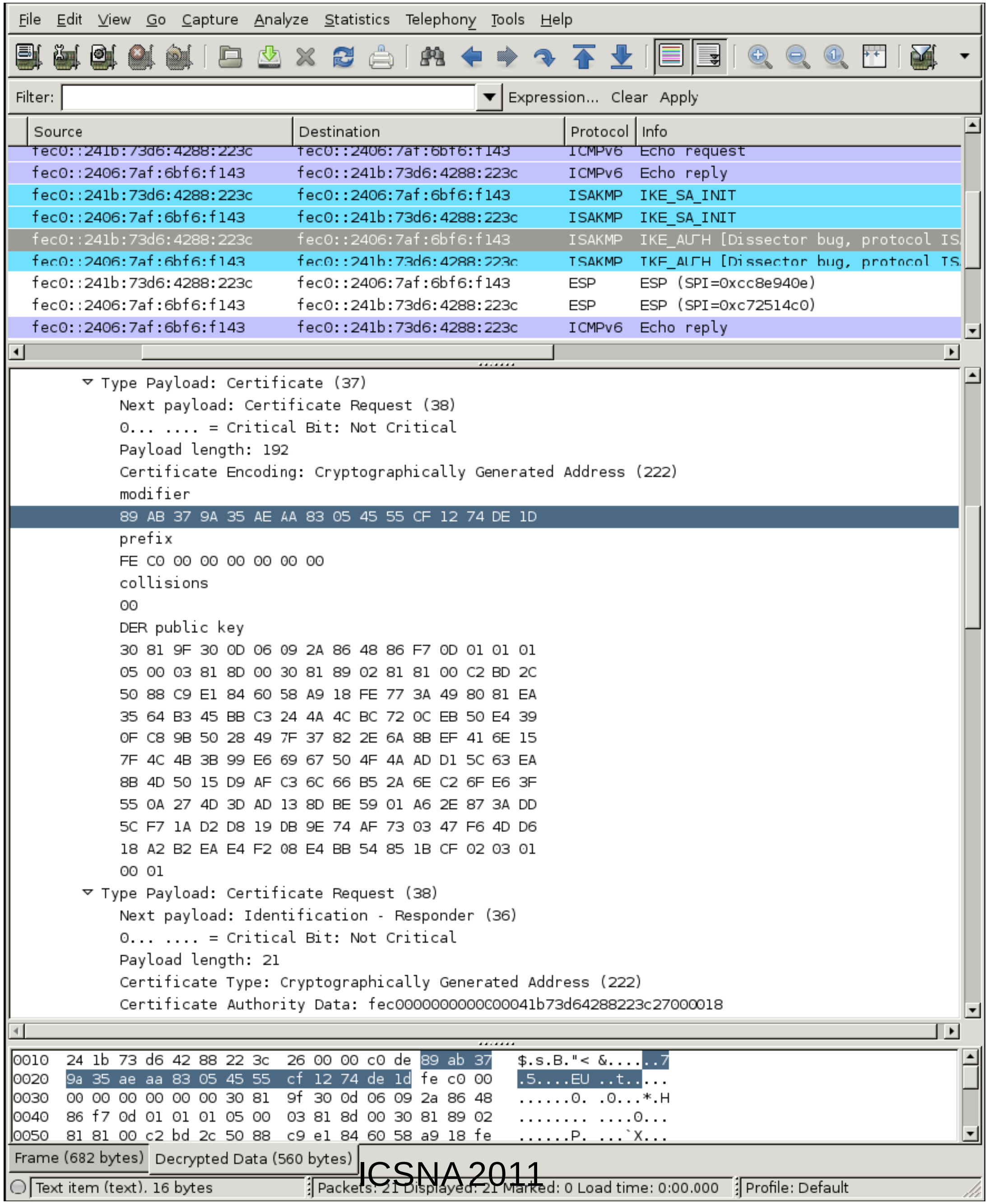
- Based on
  - StrongSwan
    - Linux IPsec/IKEv2 implementation
  - Docomo USA Labs
    - FreeBSD/Linux SEND/CGA implementation
- Debian

Implementation (2/3)

- StrongSwan modifications
  - IPsec configuration file parser
  - IKEv2 payloads(ID, CERTREQ, CERT)
    - CERT: new plugin for StrongSwan
  - IKEv2 AUTH
  - IKEv2 State Machine (AUTH checking)
    - CGA ownership checking

Implementation (3/3)

- Wireshark
  - Plugin to check the IKEv2+CGA exchanges



File Edit View Go Capture Analyze Statistics Telephony Tools Help
Filter:
Expression... Clear Apply

```
Source                      Destination                 Protocol  Info
fec0::241b:73d6:4288:223c   fec0::2406:7af:6bf6:f143    ICMPv6    Echo request
fec0::2406:7af:6bf6:f143    fec0::241b:73d6:4288:223c   ICMPv6    Echo reply
fec0::241b:73d6:4288:223c   fec0::2406:7af:6bf6:f143    ISAKMP    IKE_SA_INIT
fec0::2406:7af:6bf6:f143    fec0::241b:73d6:4288:223c   ISAKMP    IKE_SA_INIT
fec0::241b:73d6:4288:223c   fec0::2406:7af:6bf6:f143    ISAKMP    IKE_AUTH [Dissector bug, protocol IS
fec0::2406:7af:6bf6:f143    fec0::241b:73d6:4288:223c   ISAKMP    IKE_AUTH [Dissector bug, protocol IS
fec0::241b:73d6:4288:223c   fec0::2406:7af:6bf6:f143    ESP       ESP (SPI=0xcc8e940e)
fec0::2406:7af:6bf6:f143    fec0::241b:73d6:4288:223c   ESP       ESP (SPI=0xc72514c0)
fec0::2406:7af:6bf6:f143    fec0::241b:73d6:4288:223c   ICMPv6    Echo reply
```

```
▽ Type Payload: Certificate (37)
    Next payload: Certificate Request (38)
    0... .... = Critical Bit: Not Critical
    Payload length: 192
    Certificate Encoding: Cryptographically Generated Address (222)
    modifier
    89 AB 37 9A 35 AE AA 83 05 45 55 CF 12 74 DE 1D
    prefix
    FE C0 00 00 00 00 00 00
    collisions
    00
    DER public key
    30 81 9F 30 0D 06 09 2A 86 48 86 F7 0D 01 01 01
    05 00 03 81 8D 00 30 81 89 02 81 81 00 C2 BD 2C
    50 88 C9 E1 84 60 58 A9 18 FE 77 3A 49 80 81 EA
    35 64 B3 45 BB C3 24 4A 4C BC 72 0C EB 50 E4 39
    0F C8 9B 50 28 49 7F 37 82 2E 6A 8B EF 41 6E 15
    7F 4C 4B 3B 99 E6 69 67 50 4F 4A AD D1 5C 63 EA
    8B 4D 50 15 D9 AF C3 6C 66 B5 2A 6E C2 6F E6 3F
    55 0A 27 4D 3D AD 13 8D BE 59 01 A6 2E 87 3A DD
    5C F7 1A D2 D8 19 DB 9E 74 AF 73 03 47 F6 4D D6
    18 A2 B2 EA E4 F2 08 E4 BB 54 85 1B CF 02 03 01
    00 01
▽ Type Payload: Certificate Request (38)
    Next payload: Identification - Responder (36)
    0... .... = Critical Bit: Not Critical
    Payload length: 21
    Certificate Type: Cryptographically Generated Address (222)
    Certificate Authority Data: fec0000000000c00041b73d64288223c27000018
```

```
0010  24 1b 73 d6 42 88 22 3c  26 00 00 c0 de 89 ab 37   $.s.B."< &.......7
0020  9a 35 ae aa 83 05 45 55  cf 12 74 de 1d fe c0 00   .5....EU ..t.....
0030  00 00 00 00 00 00 30 81  9f 30 0d 06 09 2a 86 48   ......0. .0...*.H
0040  86 f7 0d 01 01 01 05 00  03 81 8d 00 30 81 89 02   ........ ....0...
0050  81 81 00 c2 bd 2c 50 88  c9 e1 84 60 58 a9 18 fe   ......P. ...`X...
```

Frame (682 bytes)
Decrypted Data (560 bytes)
Text item (text). 16 bytes
Packets: 21 Displayed: 21 Marked: 0 Load time: 0:00.000
Profile: Default

Outline

- IPsec
- IKEv2
- CGA
- IKEv2 with CGA?
- IKEv2 exchanges
- IPsec/IKEv2 modifications
- Implementation
- **IKEv2+CGA improvements**
- Conclusion

IKEv2+CGA improvements (1/2)

- Identity: DNS use
  - To keep same security level
    - DNSSEC: FQDN <-> CGA
    - TSIG, SIG(0): for the CGA registration
  - Partially implemented (issue with StrongSwan)
    - Based on BIND

IKEv2+CGA improvements (2/2)

- "Hard-coded" cryptographic algorithms
  - SHA-1
    - Replaced by SHA-3 in CGA IETF RFC
  - RSA
    - Allow ECC use
- No revocation
  - Potential solution based on Time To Live (TTL) field in DNS ressource records???

Outline

- IPsec
- IKEv2
- CGA
- IKEv2 with CGA?
- IKEv2 exchanges
- IPsec/IKEv2 modifications
- Implementation
- IKEv2+CGA improvements
- **Conclusion**

Conclusion

- IKEv2+CGA works
  - – Implementation (PoC)
- CGA RFC needs modifications
  - – SHA-3 and ECC integrations
- IKEv2+CGA with DNSSEC
  - – Needs of more works on (i.e., a PoC)
- CGA revocation
  - – Still an open issue …

Questions?

Thanks!

References

[RFC4301]

S. Kent and K. Seo. Security Architecture for the Internet Protocol. RFC 4301, Internet Engineering Task Force, December 2005.

[RFC5996]

C. Kaufman, P. Homan, Y. Nir, and P. Eronen. Internet Key Exchange Protocol Version 2 (IKEv2). RFC 5996, Internet Engineering Task Force, September 2010.

[RFC3972]

T. Aura. Cryptographically Generated Addresses (CGA). RFC 3972, Internet Engineering Task Force, March 2005.

[RFC3971]

J. Arkko, J. Kempf, B. Zill, and P. Nikander. SEcure Neighbor Discovery (SEND). RFC 3971, Internet Engineering Task Force, March 2005.

[CMLN04]

Claude Castelluccia, Gabriel Montenegro, Julien Laganier, and Christoph Neumann. Hindering eavesdropping via ipv6 opportunistic encryption. In in Proceedings of the European Symposium on Research in Computer Security, Lecture Notes in Computer Science, pages 309{321. Springer-Verlag, 2004.

[LMK07]

J. Laganier, G. Montenegro, and A. Kukec. Using IKE with IPv6 Cryptographically Generated Addresses. Internet-Draft draft-laganier-ike-ipv6-cga-02, Internet Engineering Task Force, July 2007. Obsolete.

StrongSwan

http://www.strongswan.org/

Wireshark

http://www.wireshark.org/