
Ephemeral Diffie-Hellman
Over COSE (EDHOC)
draft-ietf-lake-edhoc-00
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Introduction

- Lightweight authenticated key exchange protocol
- Matching the LAKE requirements [1]
  - Performance benchmarks
  - Reusing building blocks used by OSCORE [2]

- CBOR [3] for encoding
- COSE [4] for CBOR-encoded crypto, identification of algorithms, curves, credentials, etc.
- CoAP [5] for transport (default), and also handling message loss/ re-ordering /de-duplication/fragmentation and certain DoS mitigation

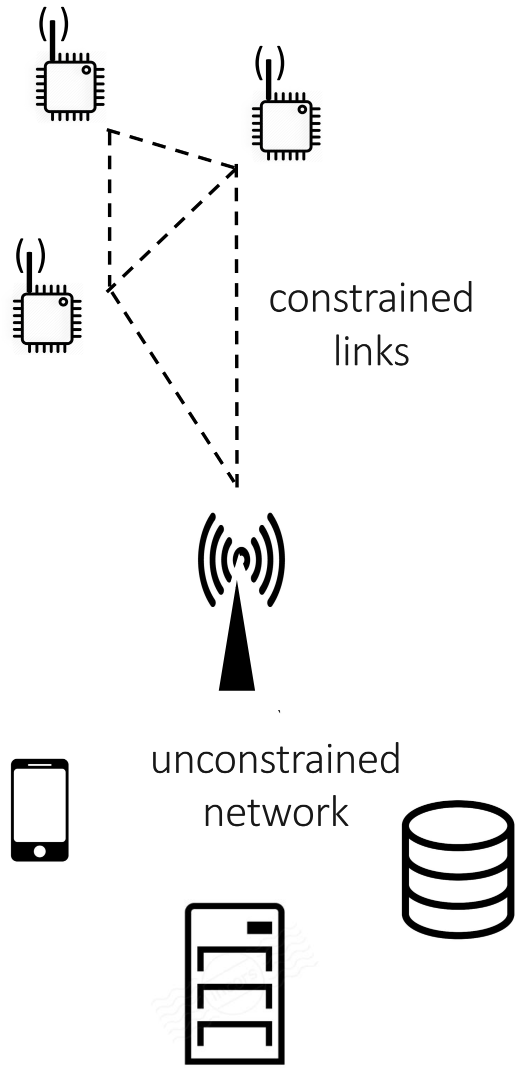
NOTE: Separate presentation of security claims

[1] draft-ietf-lake-reqs
[2] RFC 8613
[3] RFC 7049
[4] RFC 8152
[5] RFC 7252

Applications

- General: Establish good quality keys for protecting communication between sensor/actuator and cloud/edge over constrained links

- Specific: Constrained device joins network
- Variations
  - Network conditions
    - Multi-hop constrained network
    - Network formation with large number of devices
  - Concurrent security application
    - Third party assisted authorization
    - Enrolment of operational device certificate
  - Credential management
    - Pre-provisioned credentials
    - References to credentials



Protocol Messages

- 3 messages
- Additional error message
- Each message is a sequence of CBOR encoded data (RFC 8742)

G_. = Public DH key
C_. = Connection id.
K_. = Symmetric key
AD_. = Auxiliary data

```
Initiator                                                   Responder
|               METHOD_CORR, SUITES_I, G_X, C_I, AD_1               |
+------------------------------------------------------------------>|
|                            message_1                              |
|                                                                   |
|   C_I, G_Y, C_R, Enc(K_2e; ID_CRED_R, Signature_or_MAC_2, AD_2)   |
|<------------------------------------------------------------------+
|                            message_2                              |
|                                                                   |
|       C_R, AEAD(K_3ae; ID_CRED_I, Signature_or_MAC_3, AD_3)       |
+------------------------------------------------------------------>|
|                            message_3                              |
```

Diffie-Hellman, Encryption, Signature_or_MAC

- Fresh ephemeral public keys G_X, G_Y
- Message 2 has Enc (XOR), message 3 has AEAD
- Signature_or_MAC is either MAC-then-sign or MAC depending on authentication method

G_. = Public DH key
C_. = Connection id.
K_. = Symmetric key
AD_. = Auxiliary data

```
Initiator                                                  Responder
|          METHOD_CORR, SUITES_I, G_X, C_I, AD_1                  |
+---------------------------------------------------------------->|
|                           message_1                              |
|                                                                  |
|  C_I, G_Y, C_R, Enc(K_2e; ID_CRED_R, Signature_or_MAC_2, AD_2)   |
|<----------------------------------------------------------------+
|                           message_2                              |
|                                                                  |
|      C_R, AEAD(K_3ae; ID_CRED_I, Signature_or_MAC_3, AD_3)       |
+---------------------------------------------------------------->|
|                           message_3                              |
```

Authentication Methods

— 4 methods in the initial scope

Value	Initiator	Responder	Reference
0	Signature Key	Signature Key	[[this document]]
1	Signature Key	Static DH Key	[[this document]]
2	Static DH Key	Signature Key	[[this document]]
3	Static DH Key	Static DH Key	[[this document]]

— Targeting IoT use cases, for example:
  — IEEE 802.1AR device certificates, device certificate enrolment (signature based)
  — Pre-provisioned RPK, minimal overhead (static DH based)
  — Mix of RPK and certificate (mixed static DH and signature)

Methods, Message Correlation, Connection Identifiers

- METHOD_CORR (int) = 4 * method + corr
  - method = 0, 1, 2, 3
  - corr = 0, 1, 2, 3 encodes correlation between messages provided by transport
- C_I, C_R (bstr/int): Explicit connection identifiers, may be omitted in case of message correlation

```
Initiator                                                       Responder
|               METHOD_CORR, SUITES_I, G_X, C_I, AD_1                   |
+---------------------------------------------------------------------->|
|                               message_1                               |
|                                                                       |
|  C_I, G_Y, C_R, Enc(K_2e; ID_CRED_R, Signature_or_MAC_2, AD_2)        |
|<----------------------------------------------------------------------+
|                               message_2                               |
|                                                                       |
|      C_R, AEAD(K_3ae; ID_CRED_I, Signature_or_MAC_3, AD_3)            |
+---------------------------------------------------------------------->|
|                               message_3                               |
```

Cipher suites 1(3)

- Cipher suite = ordered set of COSE code points
  - For EDHOC: AEAD, hash, ECDH curve, signature algorithm, signature algorithm curve
  - For the application (OSCORE): AEAD and hash algorithm
- Method defines how cipher suite is used

```
0. ( 10, -16, 4, -8, 6, 10, -16 )
   (AES-CCM-16-64-128, SHA-256, X25519, EdDSA, Ed25519,
    AES-CCM-16-64-128, SHA-256)

1. ( 30, -16, 4, -8, 6, 10, -16 )
   (AES-CCM-16-128-128, SHA-256, X25519, EdDSA, Ed25519,
    AES-CCM-16-64-128, SHA-256)

2. ( 10, -16, 1, -7, 1, 10, -16 )
   (AES-CCM-16-64-128, SHA-256, P-256, ES256, P-256,
    AES-CCM-16-64-128, SHA-256)

3. ( 30, -16, 1, -7, 1, 10, -16 )
   (AES-CCM-16-128-128, SHA-256, P-256, ES256, P-256,
    AES-CCM-16-64-128, SHA-256)
```

Cipher suites 2(3)

- suite = int
- SUITES_I : [selected : suite, supported : 2* suite] / suite
  - supported = cipher suites which the Initiator supports in order of preference
    - can be truncated at the end
  - selected = selected cipher suite by the Initiator

G_. = Public DH key
C_. = Connection id.
K_. = Symmetric key
AD_. = Auxiliary data

```
Initiator                                                       Responder
|               METHOD_CORR, SUITES_I, G_X, C_I, AD_1                    |
+----------------------------------------------------------------------->|
|                             message_1                                  |
|                                                                        |
|   C_I, G_Y, C_R, Enc(K_2e; ID_CRED_R, Signature_or_MAC_2, AD_2)        |
|<-----------------------------------------------------------------------+
|                             message_2                                  |
|                                                                        |
|       C_R, AEAD(K_3ae; ID_CRED_I, Signature_or_MAC_3, AD_3)            |
+----------------------------------------------------------------------->|
|                             message_3                                  |
```

Error Message, Cipher suites 3(3)

G_. = Public DH key
C_. = Connection id.
K_. = Symmetric key
AD_. = Auxiliary data

- error = (? C_., ERR_MSG, ? SUITES_R)
  - ERR_MSG = tstr
  - SUITES_R : [supported : 2* suite] / suite
    - supported = cipher suites in SUITES_I supported by the Responder
- Example of error message: Figure below shows Responder supporting cipher suite 6, but not 5

```
Initiator                                                          Responder
|          METHOD_CORR, SUITES_I = [5, 5, 6, 7], G_X, C_I, AD_1          |
+----------------------------------------------------------------------->|
|                              message_1                                 |
|                                                                        |
|                   C_I, ERR_MSG, SUITES_R = 6                           |
|<-----------------------------------------------------------------------+
|                                error                                   |
|                                                                        |
|           METHOD_CORR, SUITES_I = [6, 5, 6], G_X, C_I, AD_1            |
+----------------------------------------------------------------------->|
|                              message_1                                 |
```

Credentials and Identifiers

- ID_CRED_I and ID_CRED_R are COSE header_maps (CBOR maps using IANA ”COSE Header Parameters”)
  - used to enable retrieval of credential (CRED_I and CRED_R, resp.)
  - RPK may be identified with a ‘kid’ (RFC 8152)
  - Certificates may be identified with ‘x5t’, ‘x5u’ (draft-ietf-cose-x509)
- CRED_I and CRED_R covered by Signature_or_MAC

```
Initiator                                                   Responder
|               METHOD_CORR, SUITES_I, G_X, C_I, AD_1               |
+------------------------------------------------------------------>|
|                             message_1                             |
|                                                                   |
|   C_I, G_Y, C_R, Enc(K_2e; ID_CRED_R, Signature_or_MAC_2, AD_2)   |
|<------------------------------------------------------------------+
|                             message_2                             |
|                                                                   |
|       C_R, AEAD(K_3ae; ID_CRED_I, Signature_or_MAC_3, AD_3)       |
+------------------------------------------------------------------>|
|                             message_3                             |
```

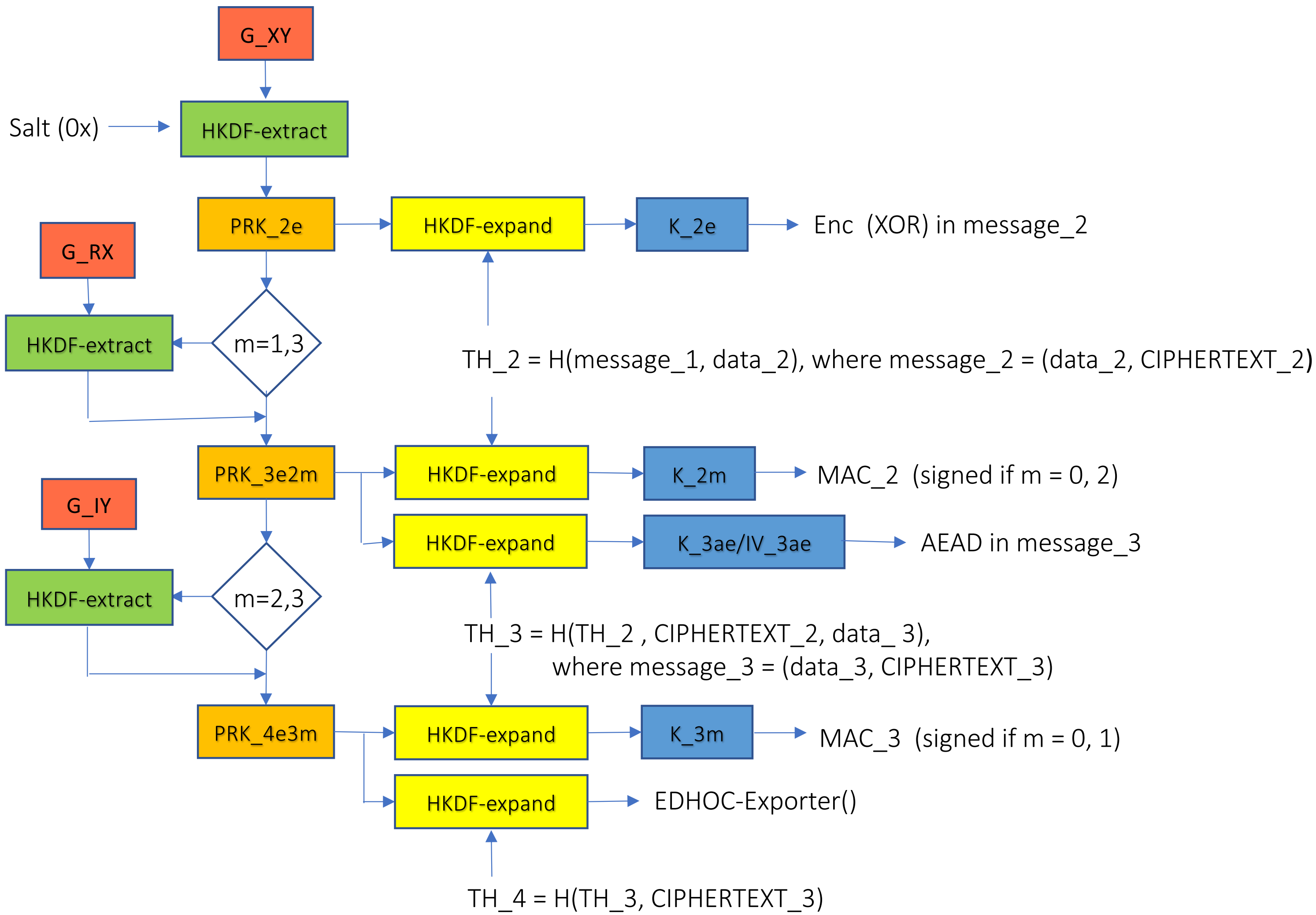
Keys

method (m) = 0, 1, 2, 3

DH-keys

Responder:
Ephemeral G_Y
Static G_R (m = 1, 3)

Initiator:
Ephemeral G_X
Static G_I (m = 2, 3)



DH-shared secret

Pseudo-random key

Encryption/MAC key

Auxiliary Data

- AD_1, AD_2, AD_3
- Integration points for EDHOC in lightweight security applications, such as
  - Third party authorization, e.g., draft-selander-ace-ake-authz (figure below)
  - Enrolment of device certificate

```
                   AD_1 =
              EDHOC  Voucher Info
+----------+  |    |   +---------------+  Voucher  +---------------+
|          |  |    |   |               |  Request  |               |
|  Device  |--|----o-->|    Domain     |---------->| Authorization |
|          |<-|---o----| Authenticator |<----------|     Server    |
|    (U)   |--|---|--->|      (V)      |  Voucher  |      (W)      |
|          |      |    |               |  Response |               |
+----------+      |    +---------------+           +---------------+
                  AD_2 = Voucher
```

CoAP Transport and OSCORE Context

- EDHOC may be mapped to CoAP POST / 2.04 (Changed)
- Initiator may be CoAP Client or CoAP Server
  - The former assumed here
- OSCORE request/response may be included in second roundtrip, see [draft-palombini-core-oscore-edhoc]
- OSCORE security context:
  - Client SenderID = C_R
  - Server SenderID = C_I
  - Master Secret/Salt derived with EDHOC-Exporter()
  - Algs. according to cipher suite

```
Client    Server
  |          |
  +--------->| Header: POST (Code=0.02)
  |   POST   | Uri-Path: "/.well-known/edhoc"
  |          | Content-Format: application/edhoc
  |          | Payload: EDHOC message_1
  |          |
  |<---------+ Header: 2.04 Changed
  |   2.04   | Content-Format: application/edhoc
  |          | Payload: EDHOC message_2
  |          |
  +--------->| Header: POST (Code=0.02)
  |   POST   | Uri-Path: "/.well-known/edhoc"
  |          | Content-Format: application/edhoc
  |          | Payload: EDHOC message_3
  |          |
  |<---------+ Header: 2.04 Changed
  |   2.04   |
  |          |
```

Code

- Several implementations announced/in progress, including:
  - Univ. of Fribourg/Martin Disch
    - https://github.com/martindisch/oscore
  - Fraunhofer AISEC/Stefan Hristozov
  - Univ. of Murcia/Eduardo Ingles

- Code to generate test vectors
  - https://github.com/EricssonResearch/EDHOC/tree/master/Test%20Vectors