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Lightweight Authorization using Ephemeral Diffie-Hellman Over COSE (ELA) draft-ietf-lake-authz-05

Abstract

Ephemeral Diffie-Hellman Over COSE (EDHOC) is a lightweight authenticated key exchange protocol intended for use in constrained scenarios. This document specifies Lightweight Authorization using EDHOC (ELA). The procedure allows authorizing enrollment of new devices using the extension point defined in EDHOC. ELA is applicable to zero-touch onboarding of new devices to a constrained network leveraging trust anchors installed at manufacture time.

About This Document

This note is to be removed before publishing as an RFC.

The latest revision of this draft can be found at https://lake-wg.github.io/authz/draft-ietf-lake-authz.html. Status information for this document may be found at https://datatracker.ietf.org/doc/draft-ietf-lake-authz/.

Discussion of this document takes place on the Lightweight Authenticated Key Exchange Working Group mailing list (mailto:lake@ietf.org), which is archived at https://mailarchive.ietf.org/arch/browse/lake/. Subscribe at https://www.ietf.org/mailman/listinfo/lake/.

Source for this draft and an issue tracker can be found at https://github.com/lake-wg/authz.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

This Internet-Draft will expire on 8 January 2026.

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1. Introduction

For constrained IoT deployments [RFC7228] the overhead and processing contributed by security protocols may be significant, which motivates the specification of lightweight protocols that are optimizing, in particular, message overhead (see [I-D.ietf-lake-reqs]). This document describes Lightweight Authorization using EDHOC (ELA), a procedure for augmenting the lightweight authenticated Diffie-Hellman key exchange EDHOC [RFC9528] with third party-assisted authorization.

ELA involves a device, a domain authenticator, and an enrollment server. The device and domain authenticator perform mutual authentication and authorization, assisted by the enrollment server that provides relevant authorization information to the device (a "voucher") and to the authenticator. The high-level model is similar to BRSKI [RFC8995].

In this document, we consider the target interaction for which authorization is needed to be "enrollment", for example joining a network for the first time (e.g., [RFC9031]), but it can be applied to authorize other target interactions.

The enrollment server may represent the manufacturer of the device, or some other party with information about the device from which a trust anchor has been pre-provisioned into the device. The (domain) authenticator may represent the service provider or some other party controlling access to the network in which the device is enrolling.

ELA assumes that authentication between device and authenticator is performed with EDHOC [RFC9528], and defines the integration of a lightweight authorization procedure using the External Authorization Data (EAD) fields defined in EDHOC.

ELA enables a low message count by performing authorization and enrollment in parallel with authentication, instead of in sequence, which is common for network access. It further reuses protocol elements from EDHOC, leading to reduced message sizes on constrained links.

This protocol is applicable to a wide variety of settings, and can be mapped to different authorization architectures.

1.1. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

Readers are expected to have an understanding of CBOR [RFC8949], CDDL [RFC8610], and EDHOC [RFC9528]. Appendix C.1 of [RFC9528] contains some basic info about CBOR.

2. Protocol Outline

The goal of ELA is to enable a (potentially constrained) device (U) to enroll into a domain over a constrained link. The device authenticates and enforces authorization of the (non-constrained) domain authenticator (V) with the help of a voucher conveying authorization information. The voucher has a similar role as in [RFC8366] but should be considerably more compact. The domain authenticator, in turn, authenticates the device and authorizes its enrollment into the domain.

The procedure is assisted by a (non-constrained) enrollment server (W) located in a non-constrained network behind the domain authenticator, e.g., on the Internet, providing information to the device (conveyed in the voucher) and to the domain authenticator as part of the protocol.

The objective of this document is to specify such a protocol that is lightweight over the constrained link, by reusing elements of EDHOC [RFC9528] and by shifting message overhead to the non-constrained side of the network. See illustration in Figure 1.

Note the cardinality of the involved parties. It is expected that the domain authenticator needs to handle a large unspecified number of devices, but for a given device type or manufacturer it is expected that one or a few nodes host enrollment servers.

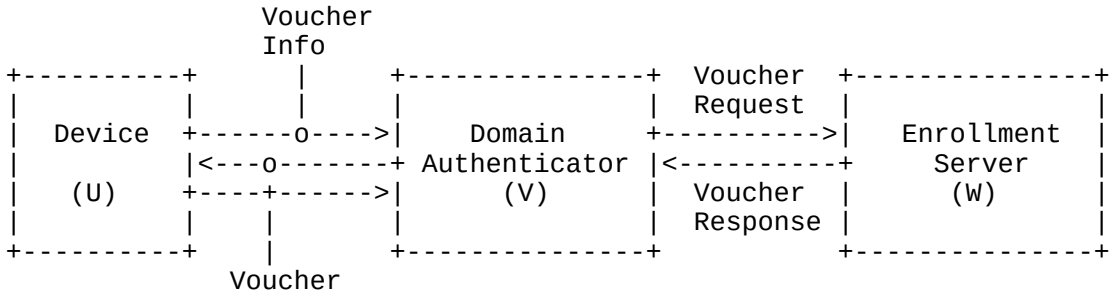


Figure 1: Overview of the message flow. EDHOC is used on the constrained link between U and V. Voucher Info and Voucher are sent in EDHOC External Authorization Data (EAD). The link between V and W is not constrained.

3. Assumptions

The protocol is based on the following pre-existing relations between the device (U), the domain authenticator (V) and the enrollment server (W), see Figure 2.

* U and W have an explicit relation: U is configured with a public key of W, see Section 3.1.

* V and W have an implicit relation, e.g., based on web PKI with trusted CA certificates, see Section 3.2.

* U and V need not have any previous relation. This protocol establishes a relation between U and V.

Each of the three parties can gain protected communication with the other two during the protocol.

V may be able to access credentials over non-constrained networks, but U may be limited to constrained networks. Implementations wishing to leverage the zero-touch capabilities of this protocol are expected to support transmission of credentials from V to U by value during the EDHOC exchange, which will impact the message size depending on the type of credential used.

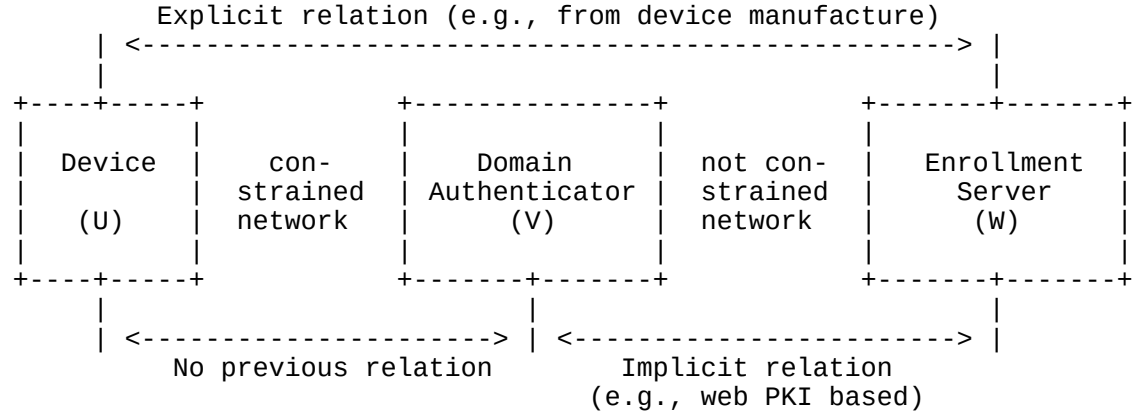


Figure 2: Overview of pre-existing relations.

3.1. Device (U)

To authenticate to V, the device (U) runs EDHOC in the role of Initiator with authentication credential CRED_U, for example, an X.509 certificate [RFC5280] or a CBOR Web Token (CWT, [RFC8392]). CRED_U may, for example, be carried by value in ID_CRED_I of EDHOC message_3 or be provisioned to V over a non-constrained network, leveraging a credential identifier in ID_CRED_I (see bottom of Figure 3).

U also needs to identify itself to W. The device identifier used for this is ID_U. The purpose of ID_U is for W to be able to determine if the device with this identifier is authorized to enroll with V. ID_U may be a reference to CRED_U, like ID_CRED_I in EDHOC (see Section 3.5.2 of [RFC9528]), or a device identifier from a different name space, such as EUI-64 identifiers.

U is also provisioned with information about W:

* A static public DH key of W (G_W) used to establish secure communication with the enrollment server (see Section 4.4).

* Location information about the enrollment server (LOC_W) that can be used by V to reach W. This is typically a URI but may alternatively be only the domain name.

3.2. Domain Authenticator (V)

To authenticate to U, the domain authenticator (V) runs EDHOC in the role of Responder with an authentication credential CRED_V containing a public key of V, see Section 4.5.2.1. This proves to U the possession of the private key corresponding to the public key of CRED_V. CRED_V typically needs to be transported to U in EDHOC (using ID_CRED_R = CRED_V, see Section 3.5.2 of [RFC9528]) since there is no previous relation between U and V.

V and W need to establish a secure (confidentiality and integrity protected) connection for the Voucher Request/Response protocol. Furthermore, W needs to access the same credential CRED_V that V uses with U (to compute the Voucher), and V needs to prove to W the possession of the private key corresponding to the public key of CRED_V. It is RECOMMENDED that V authenticates to W using the same credential CRED_V as with U.

Note that the choice of protocols may affect which type of credential and methods should be used by V. For example, in case V and W select TLS for the secure channel and PoP, then CRED_V is a X.509 certificate, and the EDHOC method used by V is signature-based. Some of the possible combinations of protocols to secure the connection between V and W are listed in Table 1 below.

Secure channel between V and W	Proof-of-Possession from V to W	Type of CRED_V	EDHOC method used by V
[D]TLS 1.3 with mutual authentication, where V is the client and W is the server.	Provided by [D]TLS.	Restricted to types that are supported by both [D]TLS and EDHOC, e.g., X.509 certificates.	V MUST authenticate using a signature.
[D]TLS 1.3, where V is the client and W is the server.	Run an EDHOC session on top of the TLS-protected channel.	Any type supported by EDHOC, e.g., X.509, C509, CWT, or CCS.	Any method may be used.
EDHOC and OSCORE, where V is the initiator and W is the responder.	Already provided by EDHOC during the setup of the secure channel.	Any type supported by EDHOC.	Any method may be used.

Table 1: Examples of how to secure the connection between V and W.

Note also that the secure connection between V and W may be long-lived and reused for multiple voucher requests/responses.

Other details of proof-of-possession related to CRED_V and transport of CRED_V are out of scope of this document.

3.3. Enrollment Server (W)

The enrollment server (W) is assumed to have the private DH key corresponding to G_W, which is used to establish secure communication with the device (see Section 4.4). W provides to U the authorization decision for enrollment with V in the form of a voucher (see Section 4.4.2). Authorization policies are out of scope for this document.

Authentication credentials and communication security with V is described in Section 3.2. To calculate the voucher, W needs access to message_1 and CRED_V as used in the EDHOC session between U and V, see Section 4.4.2.

* W MUST verify that CRED_V is bound to the secure connection between W and V

* W MUST verify that V is in possession of the private key corresponding to the public key of CRED_V

W needs to be available during the execution of the protocol between U and V.

4. The Protocol

4.1. Overview

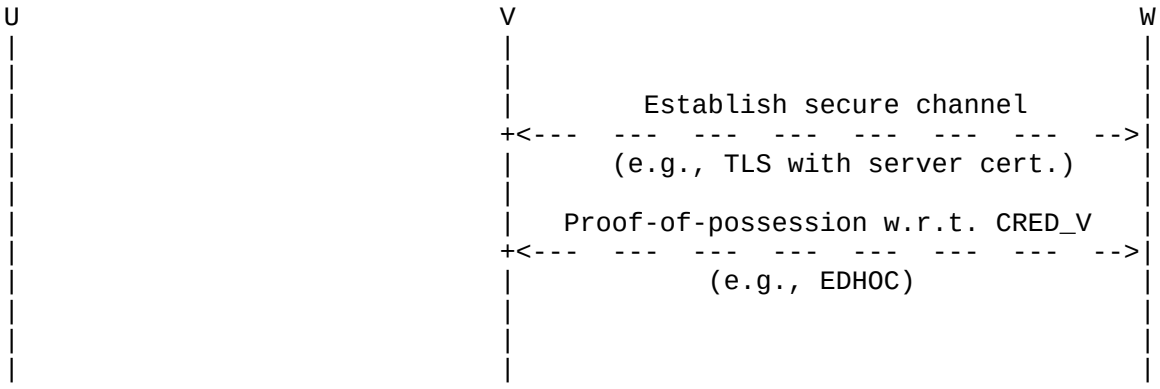
The ELA protocol consist of three security sessions going on in parallel:

1. The EDHOC session between device (U) and (domain) authenticator (V)

2. Voucher Request/Response between authenticator (V) and enrollment server (W)

3. An exchange of voucher-related information, including the voucher itself, between device (U) and enrollment server (W), mediated by the authenticator (V).

Figure 3 provides an overview of the message flow detailed in this section. An outline of EDHOC is given in Section 2 of [RFC9528].



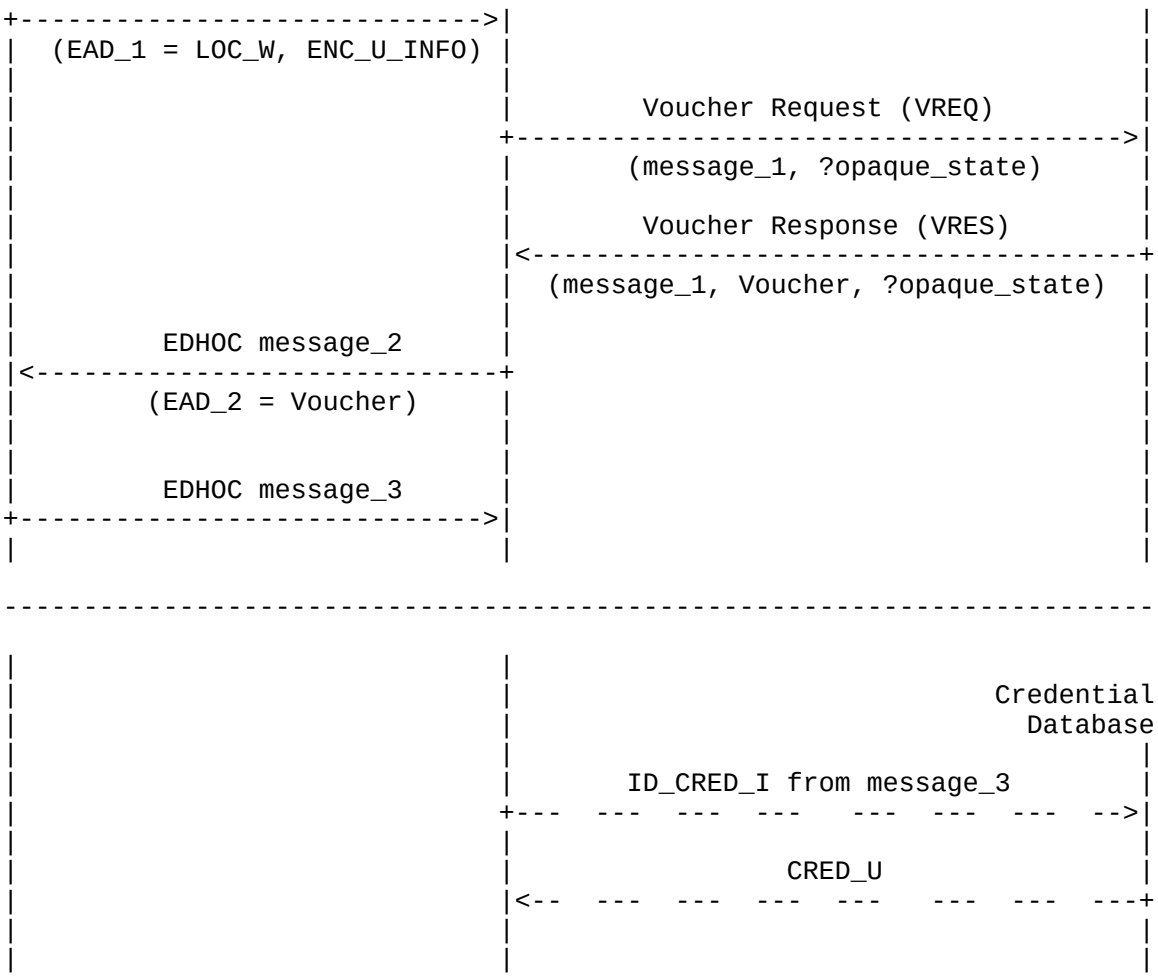


Figure 3: Overview of ELA: W-assisted authorization of U and V to each other: EDHOC between U and V, and Voucher Request/Response between V and W. Before the protocol, V and W are assumed to have established a secure channel and performed proof-of-possession of relevant keys. Credential lookup of CRED_U may involve W or other credential database.

4.2. Reuse of EDHOC

The ELA protocol illustrated in Figure 3 reuses several components of EDHOC:

* G_X, the ephemeral public Diffie-Hellman key of U, is also used in the protocol between U and W. In case U acts as Responder (see Section 4.8), G_Y is used instead.

* SUITES_I includes the cipher suite for EDHOC selected by U, and also defines the algorithms used between U and W (see Section 3.6 of [RFC9528]):

  - EDHOC AEAD algorithm: used to encrypt ID_U and to generate voucher

  - EDHOC hash algorithm: used for key derivation

  - EDHOC key exchange algorithm: used to calculate the shared secret between U and W

* EAD_1, EAD_2 are the External Authorization Data message fields of message_1 and message_2, respectively, see Section 3.8 of [RFC9528]. In case U acts as Responder (see Section 4.8), EAD_2 and EAD_3 are used in message_2 and message_3, respectively. This document specifies two new EAD items, with ead_label = TBD1 and TBD2, see Section 7.1.

* ID_CRED_I and ID_CRED_R are used to identify the authentication credentials CRED_U and CRED_V, respectively. As shown at the bottom of Figure 3, V may use W to obtain CRED_U. By default, CRED_V is transported in ID_CRED_R in message_2, see Section 4.5.2.1. In case U is Responder, CRED_V is transported in ID_CRED_I in message_3.

The protocol also reuses the EDHOC_Extract and EDHOC_Expand key derivation from EDHOC (see Section 4 of [RFC9528]).

* The intermediate pseudo-random key PRK is derived using EDHOC_Extract():

  - PRK = EDHOC_Extract(salt, IKM)

    o where salt = 0x (the zero-length byte string)

    o IKM is computed as an ECDH cofactor Diffie-Hellman shared secret from the public key of W, G_W, and the private key corresponding to G_X (or v.v.), see Section 5.7.1.2 of [NIST-800-56A].

The output keying material OKM is derived from PRK using EDHOC_Expand(), which is defined in terms of the EDHOC hash algorithm of the selected cipher suite SS, see Section 4.1.2 of [RFC9528]:

* OKM = EDHOC_Expand(PRK, info, length)

  where

```
info = (
   info_label : int,
   context : bstr,
   length : uint,
)
```

4.3. Stateless Operation of V

V may act statelessly with respect to U: the state of the EDHOC session started by U may be dropped at V until authorization from W is received. Once V has received EDHOC message_1 from U and extracted LOC_W from EAD_1, message_1 is forwarded unmodified to W in the form of a Voucher Request (see Section 4.6.1). V encapsulates the internal state that it needs to later respond to U, and sends that to W together with EDHOC message_1. This state typically contains addressing information of U (e.g., U's IP address and port number), together with any other implementation-specific parameter needed by V to respond to U. At this point, V can drop the EDHOC session that was initiated by U.

The encapsulated state MUST be protected using a uniformly-distributed (pseudo-)random key, known only to itself and specific for the current EDHOC session to prevent replay attacks of old encapsulated state.

How V serializes and encrypts its internal state is out of scope in this specification. For example, V may use CBOR and COSE.

W sends to V the voucher together with the echoed message_1, as received from U, and V's internal state, see Section 4.6.2. This allows V to act as a simple message relay until it has obtained the authorization from W to enroll U. The reception of a successful Voucher Response at V from W implies the authorization for V to enroll U. At this point, V can initialize a new EDHOC session with U, based on the message and the state retrieved from the Voucher Response from W.

Noet that while stateless operation is supported in the default flow, it is not supported in the reverse flow (see Section 4.8).

4.4. Device <-> Enrollment Server (U <-> W)

The protocol between U and W is carried between U and V in message_1 and message_2 (Section 4.5), and between V and W in the Voucher Request/Response (Section 4.6). The data is protected between the endpoints using secret keys derived from a Diffie-Hellman shared secret (see Section 4.2) as further detailed in this section.

4.4.1. Voucher Info

The external authorization data EAD_1 contains an EAD item with ead_label = TBD1 and ead_value = Voucher_Info, which is a CBOR byte string:

```
Voucher_Info = bstr .cborseq Voucher_Info_Seq

Voucher_Info_Seq = [ ; used as a CBOR sequence, not array
    LOC_W:      tstr,
    ENC_U_INFO:     bstr
]
```

where

* LOC_W is a text string used by V to locate W, e.g., a URI or a domain name.

* ENC_U_INFO is a byte string containing an encrypted identifier of U and, optionally, opaque application data prepared by U. It is calculated as follows:

ENC_U_INFO is encrypted using the EDHOC AEAD algorithm of the selected cipher suite SS specified in SUITE_I of EDHOC message_1. It consists of 'ciphertext' of COSE_Encrypt0 (Section 5.2 of [RFC9052]) computed from the following:

* The encryption key K_1 and nonce IV_1 are derived as specified below.

* 'protected' is a byte string of size 0

* 'plaintext' and 'external_aad' as below:

```
plaintext = (
    ID_U:           bstr,
)
```

```
external_aad = [ ; used as a CBOR sequence, not array
    "ELA-voucher-info": tstr, ; fixed label
    METHOD:             int,
    SS:                 int,
    C_I:                bstr
]
```

where

* "ELA-voucher-info" is a string literal for the Voucher_Info struct.

* ID_U is an identifier of the device, see Section 3.1.

* METHOD is the authentication method of EDHOC message_1.

* SS is the selected cipher suite in SUITES_I of EDHOC message_1, see Section 4.5.

* C_I is the connection identifier of EDHOC message_1.

The external_aad is wrapped in an enc_structure as defined in Section 5.3 of [RFC9052].

The derivation of K_1 = EDHOC_Expand(PRK, info, length) uses the following input to the info struct (see OKM in Section 4.2):

* info_label = 0

* context = h'' (the empty CBOR string)

* length is length of the key of the EDHOC AEAD algorithm in bytes (which is the length of K_1)

The derivation of IV_1 = EDHOC_Expand(PRK, info, length) uses the following input to the info struct (see OKM in Section 4.2):

* info_label = 1

* context = h'' (the empty CBOR string)

* length is length of the nonce of the EDHOC AEAD algorithm in bytes (which is the length of IV_1)

4.4.2. Voucher

The external authorization data EAD_2 contains an EAD item with ead_label = TBD2 and ead_value = Voucher.

The voucher is an assertion to U that W has authorized V. It is encrypted using the EDHOC AEAD algorithm of the selected cipher suite SS specified in SUITE_I of EDHOC message_1. It consists of the 'ciphertext' field of a COSE_Encrypt0 object, which is a byte string, as defined below.

Voucher = bstr

Its corresponding plaintext value consists of an opaque field that can be used by W to convey information to U, such as a voucher scope. The authentication tag present in the ciphertext is also bound to message_1 and the credential of V as described below.

* The encryption key K_2 and nonce IV_2 are derived as specified below.

* 'protected' is a byte string of size 0

* 'plaintext' and 'external_aad' as below:

```
plaintext = (
    ?OPAQUE_INFO: bstr
)

external_aad = (
    H_handshake:  bstr,
    CRED_V:        bstr,
)
```

where

* OPAQUE_INFO is an opaque field provided by the application. If present, it will contain application data that W may want to convey to U, e.g., a voucher scope. Note that OPAQUE_INFO is opaque when viewed as an information element in EDHOC. It is opaque to V, while the application in U and W can read its contents.

* H_handshake is the hash of EDHOC message_1, sent by V as part of the voucher request, see Section 4.6.1.

* CRED_V is the credential used by V to authenticate to U and W, see Section 4.5.2.1 and Table 1.

The derivation of K_2 = EDHOC_Expand(PRK, info, length) uses the following input to the info struct (see Section 4.2):

* info_label = 2

* context = h'' (the empty CBOR string)

* length is length of the key of the EDHOC AEAD algorithm in bytes

The derivation of IV_2 = EDHOC_Expand(PRK, info, length) uses the following input to the info struct (see Section 4.2):

* info_label = 3

* context = h'' (the empty CBOR string)

* length is length of the nonce of the EDHOC AEAD algorithm in bytes

4.5. Device <-> Authenticator (U <-> V)

This section describes the processing in U and V, which includes the EDHOC protocol, see Figure 3. Normal EDHOC processing is omitted here.

4.5.1. Message 1

4.5.1.1. Processing in U

U composes EDHOC message_1 using authentication method, identifiers, etc. according to an agreed application profile, see Section 3.9 of [RFC9528]. The selected cipher suite, in this document denoted SS, applies also to the interaction with W as detailed in Section 4.2, in particular, with respect to the Diffie-Hellman key agreement algorithm used between U and W. As part of the normal EDHOC processing, U generates the ephemeral public key G_X that is reused in the interaction with W, see Section 4.4.

The device sends EDHOC message_1 with EAD item (-TBD1, Voucher_Info) included in EAD_1, where Voucher_Info is specified in Section 4.4. The negative sign indicates that the EAD item is critical, see Section 3.8 of [RFC9528].

4.5.1.2. Processing in V

V receives EDHOC message_1 from U and processes it as specified in Section 5.2.3 of [RFC9528], with the additional step of processing the EAD item in EAD_1. Since the EAD item is critical, if V does not recognize it or it contains information that V cannot process, then V MUST abort the EDHOC session, see Section 3.8 of [RFC9528]. Otherwise, the ead_label = TBD1 triggers the voucher request to W as described in Section 4.6. The exchange between V and W needs to be completed successfully for the EDHOC session to be continued.

Note that the selected cipher suite SS is used both in the U <-> W and U <-> V interactions, therefore V must be ready to use the cipher suite SS set by U in message_1. That is, ELA restricts the cipher suite negotiation in order to provide a streamlined authorization flow from the perspective of U. Since V has a pre-established trusted channel with W, it has the opportunity to learn which cipher suites should be supported before any authorization attempt begins to take place.

4.5.2. Message 2

4.5.2.1. Processing in V

V receives the voucher response from W as described in Section 4.6.

V sends EDHOC message_2 to U with the critical EAD item (-TBD2, Voucher) included in EAD_2, i.e., ead_label = TBD2 and ead_value = Voucher, as specified in Section 4.4.2.

The type of CRED_V may depend on the selected mechanism for the establishment of a secure channel between V and W, See Table 1.

In case the network between U and V is constrained, it is recommended that CRED_V be a CWT Claims Set (CCS) [RFC8392]. The CCS contains the public authentication key of V encoded as a COSE_Key in the 'cnf' claim, see Section 3.5.2 of [RFC9528]. ID_CRED_R contains the CWT Claims Set with 'kccs' as COSE header_map, see Section 10.6 of [RFC9528].

4.5.2.2. Processing in U

U receives EDHOC message_2 from V and processes it as specified in Section 5.3.3 of [RFC9528], with the additional step of processing the EAD item in EAD_2.

If U does not recognize the EAD item or the EAD item contains information that U cannot process, then U MUST abort the EDHOC session, see Section 3.8 of [RFC9528]. Otherwise, U MUST verify the Voucher using H_message_1, CRED_V, and the keys derived as in Section 4.4.2. If the verification fails then U MUST abort the EDHOC session.

If OPAQUE_INFO is present, it is made available to the application.

4.5.3. Message 3

4.5.3.1. Processing in U

If all verifications are passed, then U sends EDHOC message_3.

EDHOC message_3 may be combined with an OSCORE-protected application request, see [I-D.ietf-core-oscore-edhoc].

4.5.3.2. Processing in V

V performs the normal EDHOC verifications of message_3. V may retrieve CRED_U from a Credential Database, after having learned ID_CRED_I from U.

4.6. Authenticator <-> Enrollment Server (V <-> W)

It is assumed that V and W have set up a secure connection, W has accessed the authentication credential CRED_V to be used in the EDHOC session between V and U, and that W has verified that V is in possession of the private key corresponding to CRED_V, see Section 3.2 and Section 3.3. V and W run the Voucher Request/ Response protocol over the secure connection.

4.6.1. Voucher Request

4.6.1.1. Processing in V

V sends the voucher request to W. The Voucher Request SHALL be a CBOR array as defined below:

```
Voucher_Request = [
    SS:             int,
    G_U:            bstr,
    Voucher_Info:   bstr,
    H_handshake:    bstr,
    ? opaque_state: bstr
]
```

where

* SS is the selected cipher suite used in the EDHOC session between U and V

* G_U is the ephemeral public key (G_X) of U

* Voucher_Info is as extracted from the EAD_1 field of message_1

* H_handshake is the hash of message_1. It is computed using the EDHOC hash algorithm of the selected cipher suite SS specified in SUITE_I of EDHOC message_1.

* opaque_state is OPTIONAL and represents the serialized and encrypted opaque state needed by V to statelessly respond to U after the reception of Voucher_Response.

4.6.1.2. Processing in W

W receives and parses the voucher request received over the secure connection with V. W extracts from Voucher_Request:

* SS - the selected cipher suite, which is the (last) integer of SUITES_I.

* G_U - the ephemeral public key of U.

* ENC_U_INFO - the encryption of the device identifier ID_U, contained in the Voucher_Info field of Voucher_Request.

* H_handshake - the hash of message_1.

W verifies and decrypts ENC_U_INFO using the relevant algorithms of the selected cipher suite SS (see Section 4.2), and obtains ID_U.

W uses H_handshake as a session identifier, and associates it to the device identifier ID_U. Note that message_1 contains a unique ephemeral key, therefore H_handshake is expected to be unique.

If processing fails up until this point, the protocol SHALL be aborted with an error code signaling a generic issue with the request, see Section 5.4.1.

W uses ID_U to look up the associated authorization policies for U and enforces them. This is out of scope for the specification.

If ID_U is known by W, but authorization fails, the protocol SHALL be aborted with an error code signaling an access control issue, see Section 4.7 and Section 5.4.1.

4.6.2. Voucher Response

4.6.2.1. Processing in W

W retrieves CRED_V associated with the secure connection with V, and constructs the Voucher for the device with identifier ID_U (see Section 4.4.2).

W generates the voucher response and sends it to V over the secure connection. The Voucher_Response SHALL be a CBOR array as defined below:

```
Voucher_Response = [
    Voucher:        bstr,
    ? opaque_state: bstr
]
```

where

* The Voucher is defined in Section 4.4.2.

* opaque_state is the echoed byte string opaque_state from Voucher_Request, if present.

W signals the successful generation of the voucher via a status code in the REST interface, as defined in Section 5.4.1.

4.6.2.2. Processing in V

V receives the voucher response from W over the secure connection. If present, V decrypts and verifies opaque_state as received from W. If that verification fails, then the EDHOC session with U is aborted. If the voucher response is successfully received from W, then V responds to U with EDHOC message_2 as described in Section 4.5.2.1.

4.7. Error Handling

This section specifies a new EDHOC error code and how it is used in ELA.

4.7.1. EDHOC Error "Access denied"

This section specifies the new EDHOC error "Access denied", see Figure 4.

ERR_CODE	ERR_INFO Type	Description
TBD3	error_content	Access denied

Figure 4: EDHOC error code and error information for ‘Access denied’.

Error code TBD3 is used to indicate to the receiver that access control has been applied and the sender has aborted the EDHOC session. The ERR_INFO field contains error_content which is a CBOR Sequence consisting of an integer and an optional byte string.

```
error_content = (
  REJECT_TYPE : int,
  ? REJECT_INFO : bstr,
)
```

The purpose of REJECT_INFO is for the sender to provide verifiable and actionable information to the receiver about the error, so that an automated action may be taken to enable access.

REJECT_TYPE	REJECT_INFO	Description
0	-	No REJECT_INFO
1	bstr	REJECT_INFO from trusted third party

Figure 5: REJECT_TYPE and REJECT_INFO for 'Access denied'.

4.7.2. Error handling in W, V, and U

ELA uses the EDHOC Error "Access denied" in the following way:

* W generates error_content and transfers it to V via the secure connection. If REJECT_TYPE is 1, then REJECT_INFO is encrypted from W to U using the EDHOC AEAD algorithm. W signals the error via an appropriate status code in the REST interface, as defined in Section 5.4.1.

* V receives error_content, prepares an EDHOC "Access denied" error, and sends it to U.

* U receives the error message and extracts the error_content. If REJECT_TYPE is 1, then U decrypts REJECT_INFO, based on which it may retry to gain access.

The encryption of REJECT_INFO follows a procedure analogous to the one defined in Section 4.4.2, with the following differences:

```
plaintext = (
    OPAQUE_INFO:     bstr,
 )
```

```
external_aad = (
    H_handshake:    bstr,
 )
```

where

* OPAQUE_INFO is an opaque field that contains actionable information about the error. It may contain, for example, a list of suggested Vs through which U should join instead.

* H_handshake is the hash of EDHOC message_1, calculated from the associated voucher request, see Section 4.6.1.

4.8. Reverse flow with U as Responder

This section presents a protocol variant in which U is the EDHOC Responder. This may allow optimizations in certain constrained network technologies. For example, one use case is having V broadcast message_1, to which U responds with a message_2 whose EAD_2 field contains Voucher_Info.

Note that this is different from the EDHOC reverse message flow defined in Appendix A.2.2 of [RFC9528], since we make no assumption about whether U or V is a CoAP server.

4.8.1. U is the Initiator

For clarity, we first present the "default flow" with U as Initiator, as described in Section 4.1 and Section 4.5. Note that Voucher_Info and Voucher are carried in EDHOC message_1 and message_2, respectively.

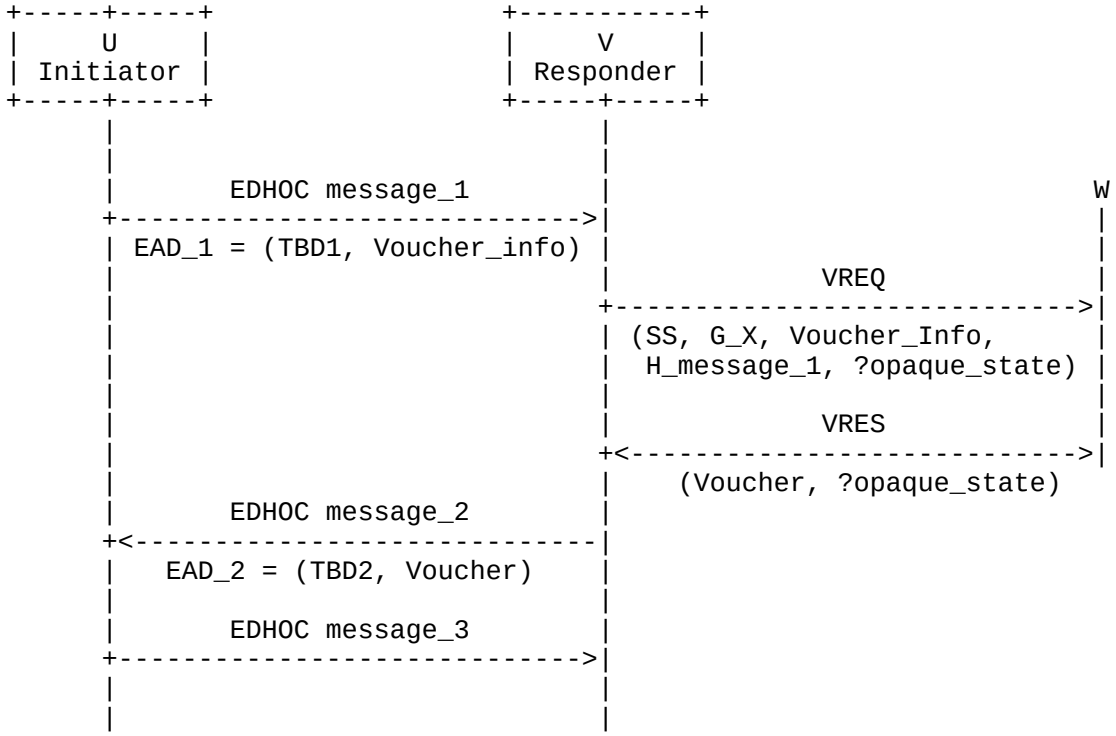


Figure 6: In ELA default flow, U is the EDHOC Initiator.

In the ELA default flow, once message_2 processing is finalized (including processing of EAD_2), U considers V authenticated through W.

4.8.2. U is the Responder

ELA also works with U as the EDHOC Responder, a setup we refer to as the "ELA reverse flow", as shown in Figure 7.

We present this variant as a set of changes to the regular protocol flow. That is, here we only describe the differences in processing, when compared to the ELA default flow.

Here is a summary of the changes needed in the ELA reverse flow:

* Voucher_Info and Voucher are transported in EDHOC message_2 and message_3, respectively (instead of message_1 and message_2).

* The EAD_2 and EAD_3 fields carry EAD items identified with labels TBD1 and TBD2, respectively.

* The VREQ / VRES protocol takes place between message_2 and message_3.

* The Voucher_Request carries G_Y instead of G_X, and the transcript hash TH_2 instead of the hash H_message_1.

* Stateless operation of V (see Section 4.3) is not supported

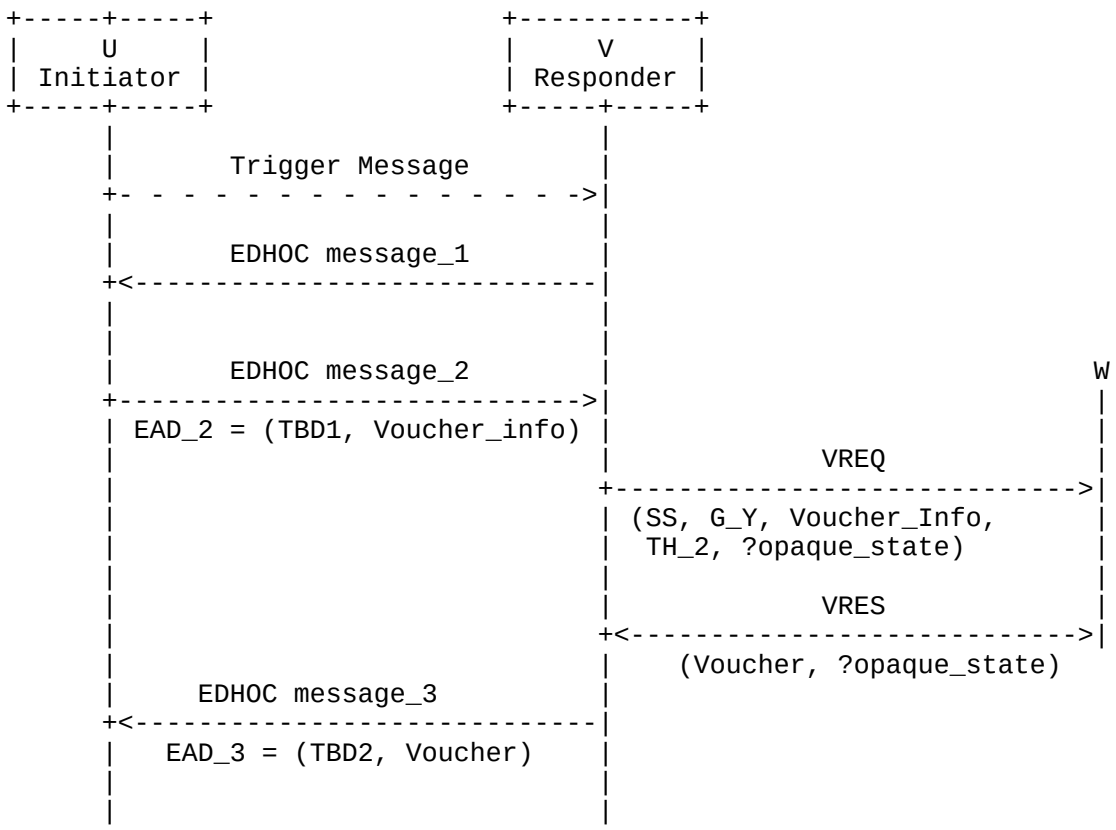


Figure 7: ELA when U is the EDHOC Responder.

The following detail how the processing changes in each of the three security sessions.

The way to interpret the subsections below is as follows. The ELA reverse flow described in this section uses most of the ELA default flow processing (Section 4.1 to Section 4.7), except by the changes detailed in Section 4.8.2.1, Section 4.8.2.2, and Section 4.8.2.3.

4.8.2.1. Reverse U <-> W

The protocol between U and W is carried between U and V in message_2 and message_3, and between V and W in the Voucher Request/Response (Section 4.6).

Voucher Info:

* The EAD_2 item has ead_label = TBD1 and ead_value = Voucher_Info.

Voucher:

* H_handshake is the transcript hash TH_2, sent by V as part of the voucher request, see Section 4.8.2.3.

4.8.2.2. Reverse U <-> V

Message 1:

* V composes message_1 and sends it to U.

* U processes message_1 and extracts SS.

Message 2:

* U composes message_2 and generates G_Y, which is reused in the interaction with W.

* U sends message_2 with EAD item (-TBD1, Voucher_Info) included in EAD_2.

* V processes message_2 and the EAD item in EAD_2, extracting the Voucher_Info struct.

* V sends the voucher request to W.

Message 3:

* V receives the voucher response from W.

* V sends message_3 with EAD item (-TBD2, Voucher) included in EAD_3.

* Y processes message_3 and the EAD item in EAD_3.

4.8.2.3. Reverse V <-> W

Processing in V:

* The Voucher_Request fields are prepared as defined in Section 4.6.1, with the following changes:

  - G_U is set to G_Y, which is the ephemeral public key of U as extracted from message_2.

  - Voucher_Info is as extracted from the EAD_2 field of message_2.

  - H_handshake is the transcript hash TH_2, computed by V as specified in Section 5.3.2 of [RFC9528].

Processing in W happens as specified in Section 4.6.1.

4.8.3. Interoperability considerations

A Device (U) MUST implement one of the ELA flows, and it MAY choose to implement both.

V MUST support the regular flow and MAY support the reverse flow.

From the point of view of W, there is no difference whether U and V run as EDHOC Initiator or Responder.

4.8.4. Security implications

When using the reverse flow, U shares its identity before it can learn (1) V’s identity and (2) whether or not the Voucher is valid.

In the reverse flow, Voucher_Info is confidentiality and integrity protected, while Voucher is also authenticated. These properties are inherited from EDHOC message_2 and message_3. This is a higher level of protection than with the regular flow.

5. REST Interface at W

The interaction between V and W is enabled through a RESTful interface exposed by W. This RESTful interface MAY be implemented using either HTTP or CoAP. V SHOULD access the resources exposed by W through the protocol indicated by the scheme in the LOC_W URI.

5.1. Scheme "https"

In case the scheme indicates "https", V MUST perform a TLS handshake with W and access the resources defined in Section 5.4 using HTTP. If the authentication credential CRED_V can be used in a TLS handshake, e.g., an X.509 certificate of a signature public key, then V SHOULD use it to authenticate to W as a client. If the authentication credential CRED_V cannot be used in a TLS handshake, e.g., if the public key is a static Diffie-Hellman key, then V SHOULD first perform a TLS handshake with W using available compatible keys. V MUST then perform an EDHOC session over the TLS connection proving to W the possession of the private key corresponding to CRED_V. Performing the EDHOC session is only necessary if V did not authenticate with CRED_V in the TLS handshake with W.

The relationship between V and W is long-lived. HTTP/1.1 and higher support persistent connections, and SHOULD be used in order to reduce overhead if a flood of new devices need to be onboarded. Support for TLS session resumptions tickets [RFC8446], Section 2.2 is appropriate for longer term associations. While a policy for renewal of the TLS connection should be applied, it is out of scope of this document.

5.2. Scheme "coaps"

In case the scheme indicates "coaps", V SHOULD perform a DTLS handshake with W and access the resources defined in Section 5.4 using CoAP. The normative requirements in Section 5.1 on performing the DTLS handshake and EDHOC session remain the same, except that TLS is replaced with DTLS. As in Section 5.1, it is RECOMMENDED to allow reuse of the DTLS session.

5.3. Scheme "coap"

In case the scheme indicates "coap", V SHOULD perform an EDHOC session with W, as specified in Appendix A of [RFC9528] and access the resources defined in Section 5.4 using OSCORE and CoAP. The authentication credential in this EDHOC session MUST be CRED_V. As in Section 5.1, it is RECOMMENDED to allow reuse of the EDHOC session.

5.4. URIs

The URIs defined below are valid for both HTTP and CoAP. W MUST support the use of the path-prefix "/.well-known/", as defined in [RFC8615], and the registered name "lake-authz". A valid URI in case of HTTP thus begins with

* "https://www.example.com/.well-known/lake-authz"

In case of CoAP with DTLS:

* "coaps://example.com/.well-known/lake-authz"

In case of EDHOC and OSCORE:

* "coap://example.com/.well-known/lake-authz"

Each operation specified in the following is indicated by a path-suffix.

5.4.1. Voucher Request (/voucherrequest)

To request a voucher, V MUST issue a request such that:

* Method is POST

* Payload is the serialization of the Voucher Request object, as specified in Section 4.6.1.

* Content-Format (Content-Type) is set to "application/lake-authz-voucherrequest+cbor"

In case of successful processing at W, W MUST issue a response such that:

* Status code is 200 OK if using HTTP, or 2.04 Changed if using CoAP

* Payload is the serialized Voucher Response object, as specified in Section 4.6.2

* Content-Format (Content-Type) is set to "application/lake-authz-voucherresponse+cbor"

In case of error, two cases should be considered:

* U cannot be identified: this happens either if W fails to process the Voucher Request, or if it succeeds but ID_U is considered unknown to W. In this case, W MUST reply with 400 Bad Request if using HTTP, or 4.00 if using CoAP.

* U is identified but unauthorized: this happens if W is able to process the Voucher Request, and W recognizes ID_U as a known device, but the access policies forbid enrollment. For example, the policy could enforce enrollment within a delimited time window, via a specific V, etc. In this case, W MUST reply with a 403 Forbidden code if using HTTP, or 4.03 if using CoAP; the payload is the serialized error_content object, with Content-

Format (Content-Type) set to "application/lake-authz-vouchererror+cbor". The payload MAY be used by V to prepare an EDHOC error "Access Denied", see Section 4.7.

5.4.2. Certificate Request (/certrequest)

V requests the public key certificate of U from W through the "/certrequest" path-suffix. To request U's authentication credential, V MUST issue a request such that:

* Method is POST
* Payload is the serialization of the ID_CRED_I object, as received in EDHOC message_3.
* Content-Format (Content-Type) is set to "application/lake-authz-certrequest+cbor"

In case of a successful lookup of the authentication credential at W, W MUST issue a response such that:

* Status code is 200 OK if using HTTP, or 2.04 Changed if using CoAP
* Payload is the serialized CRED_U
* Content-Format (Content-Type) is set to "application/lake-authz-certresponse+cbor"

6. Security Considerations

This specification builds on and reuses many of the security constructions of EDHOC, e.g., shared secret calculation and key derivation. The security considerations of EDHOC [RFC9528] apply with modifications discussed here.

EDHOC provides identity protection of the Initiator, here the device. The encryption of the device identifier ID_U in the first message should consider potential information leaking from the length of ID_U, either by making all identifiers having the same length or the use of a padding scheme.

Although W learns about the identity of U after receiving VREQ, this information must not be disclosed to V, until U has revealed its identity to V with ID_CRED_I in message_3. W may be used for lookup of CRED_U from ID_CRED_I, or this credential lookup function may be separate from the authorization function of W, see Figure 3. The trust model used here is that U decides to which V it reveals its identity. In an alternative trust model where U trusts W to decide to which V it reveals U's identity, CRED_U could be sent in Voucher Response.

As noted in Section 9.2 of [RFC9528] an ephemeral key may be used to calculate several ECDH shared secrets. In this specification, the ephemeral key G_X is also used to calculate G_XW, the shared secret with the enrollment server.

The private ephemeral key is thus used in the device for calculations of key material relating to both the authenticator and the enrollment server. There are different options for where to implement these calculations. One option is as an addition to EDHOC, i.e., to extend the EDHOC API in the device, so that EDHOC can import the public key of W (G_W) and the device identifier of U (ID_U), and then produce the encryption of ID_U which is included in Voucher_Info in EAD_1.

7. IANA Considerations

7.1. EDHOC External Authorization Data Registry

IANA has registered the following entries in the "EDHOC External Authorization Data" registry under the group name "Ephemeral Diffie-Hellman Over COSE (EDHOC)".

Label	Value Type	Description
TBD1	bstr	Voucher_Info structure, prepared by the Device (U).
TBD2	bstr	Voucher structure, prepared by the Enrollment Server (W).

Table 2: Addition to the EDHOC EAD registry

The ead_label = TBD1 corresponds to the ead_value = Voucher_Info, which can be carried in either EAD_1 or EAD_2, depending on whether U acts as EDHOC Initiator or Responder, see Section 4.8.

The ead_label = TBD2 corresponds to ead_value = Voucher, and can be carried in either EAD_2 or EAD_3, see Section 4.8.

Note for IANA reviewers: the preferred value range is 0-23 (Standards Action with Expert Review).

7.2. The Well-Known URI Registry

IANA has registered the following entry in "The Well-Known URI Registry", using the template from [RFC8615]:

* URI suffix: lake-authz

* Change controller: IETF

* Specification document: [[this document]]

* Status: permanent

* Related information: None

7.3. Well-Known Name Under ".arpa" Name Space

This document allocates a well-known name under the .arpa name space according to the rules given in [RFC3172] and [RFC6761]. The name "lake-authz.arpa" is requested. No subdomains are expected, and addition of any such subdomains requires the publication of an IETF Standards Track RFC. No A, AAAA, or PTR record is requested.

7.3.1. Domain Name Reservation Considerations

As required by [RFC6761], the following considerations apply to the reservation of "lake-authz.arpa":

1. Users: Are human users expected to recognize these names as special and use them differently? In what way?

No. This name is not intended for direct use or recognition by human users.

1. Application Software: Are writers of application software expected to make their software recognize these names as special and treat them differently? In what way? (For example, if a human user enters such a name, should the application software reject it with an error message?)

Yes. Applications that implement ELA and use CoAP may include "lake-authz.arpa" in the URI-Host option when the Device (U) does not yet know the address or identity of the Authenticator (V), such as during zero-touch enrollment.

1. Name Resolution APIs and Libraries: Are writers of name resolution APIs and libraries expected to make their software recognize these names as special and treat them differently? If so, how?

No.

1. Caching DNS Servers: Are developers of caching domain name servers expected to make their implementations recognize these names as special and treat them differently? If so, how?

No.

1. Authoritative DNS Servers: Are developers of authoritative domain name servers expected to make their implementations recognize these names as special and treat them differently? If so, how?

No.

1. DNS Server Operators: Does this reserved Special-Use Domain Name have any potential impact on DNS server operators? If they try to configure their authoritative DNS server as authoritative for this reserved name, will compliant name server software reject it as invalid? Do DNS server operators need to know about that and understand why? Even if the name server software doesn’t prevent them from using this reserved name, are there other ways that it may not work as expected, of which the DNS server operator should be aware?

No.

1. DNS Registries/Registrars: How should DNS Registries/Registrars treat requests to register this reserved domain name? Should such requests be denied? Should such requests be allowed, but only to a specially designated entity? (For example, the name "www.example.org" is reserved for documentation examples and is not available for registration; however, the name is in fact registered; and there is even a website at that name, which states circularly that the name is reserved for use in documentation and cannot be registered!)

Any requests to register this domain name should be denied.

7.4. Media Types Registry

IANA has added the media types "application/lake-authz-voucherrequest+cbor" to the "Media Types" registry.

7.4.1. application/lake-authz-voucherrequest+cbor Media Type Registration

* Type name: application
* Subtype name: lake-authz-voucherrequest+cbor
* Required parameters: N/A
* Optional parameters: N/A
* Encoding considerations: binary (CBOR)
* Security considerations: See Section 6 of this document.
* Interoperability considerations: N/A
* Published specification: [[this document]] (this document)
* Application that use this media type: To be identified
* Fragment identifier considerations: N/A
* Additional information:
  - Magic number(s): N/A
  - File extension(s): N/A
  - Macintosh file type code(s): N/A
* Person & email address to contact for further information: IETF LAKE Working Group (lake@ietf.org)
* Intended usage: COMMON
* Restrictions on usage: N/A
* Author: LAKE WG
* Change Controller: IETF

7.5. CoAP Content-Formats Registry

IANA has added the following Content-Format number in the "CoAP Content-Formats" registry under the registry group "Constrained RESTful Environments (CoRE) Parameters".

Content Type	Content Encoding	ID	Reference
application/lake-authz-voucherrequest+cbor	-	TBD3	[[this document]]

Table 3: Addition to the CoAP Content-Formats registry

Note for IANA reviewers: the preferred value range is 0-255 (Expert Review).

8. References

8.1. Normative References

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Appendix A. Optimization Strategies

When ELA is used for zero-touch enrollment of IoT devices, U may have little to no knowledge about V's available in its vicinity. This may lead to situations where U retries several times at different V's until it finds one that works. This section presents two optimization strategies for such cases. They were developed to address scenarios where V's are radio gateways to which U wants to enroll, but may also be applicable to other use cases.

A.1. U broadcasts message_1

This strategy consists in U broadcasting EDHOC message_1. When each of the V's in radio range of U receive message_1, one of the following can happen:

* V does not implement EDHOC, and drops the message
* V does not implement ELA, and drops the message (even though the EAD_1 option is critical, broadcast messages should not have error replies)
* V forwards message_1 to W as VREQ, but W does not authorize it, and error handling is applied
* V forwards message_1 to W as VREQ, W authorizes it, and the protocol continues normally

U is expected to receive and process at most one message_2 as response, which contains the Voucher. In case U receives additional message_2's, they MUST be silently dropped.

This strategy may increase the number of messages that need to be processed by V and W, in exchange for reducing resource usage in U.

Security concerns related to this strategy, including potential reuse of G_X and double processing of message_2, are discussed in Section 6.

A.2. V advertises support for ELA

In this strategy, V shares some information (V_INFO) with a potential U, that can help it decide whether to try to enroll with that V.

The exact contents of the V_INFO structure, as well as the mechanism used to transport it, will depend on the underlying communication technology and also on application needs. For example, V_INFO may state that:

* V implements ELA -- similarly to how EAPOL [IEEE802.1X] frames state support for IEEE 802.1X.

* V is part of a certain domain -- similarly to how Eduroam [RFC7593] is used in the SSID field of IEEE 802.11 packets

V_INFO can be sent over a network beacon (see Appendix A.2.1), which may require technology specific profiling, e.g., the IEEE 802.15.4 enhanced beacon may be extended according to [RFC8137]. Alternatively, V_INFO can be sent as part of an EAD field, as shown in Appendix A.2.2.

As a guideline for implementers, we define the following field that can be included in a V_INFO structure:

DOMAIN_ID: bstr

The DOMAIN_ID field identifies the domain to which V belongs to, for example an URL or UUID.

Below are three examples of how the advertisement strategy may be applied according to different application needs. The examples include sending V_INFO in network beacons, as part of EAD_1 in reverse message flow, or as part of a periodic CoAP multicast packet. The advantages, costs, and security impacts of each approach are also discussed.

A.2.1. V_INFO in network beacons

This approach allows carrying V_INFO in beacons sent over the network layer, as shown in Figure 8. It requires that the network layer offers a mechanism to configure its beacon packets. Depending on the network type, a solicitation packet may also be needed, as is the case of non-beaconed IEEE 802.15.4 and BLE with GATT.

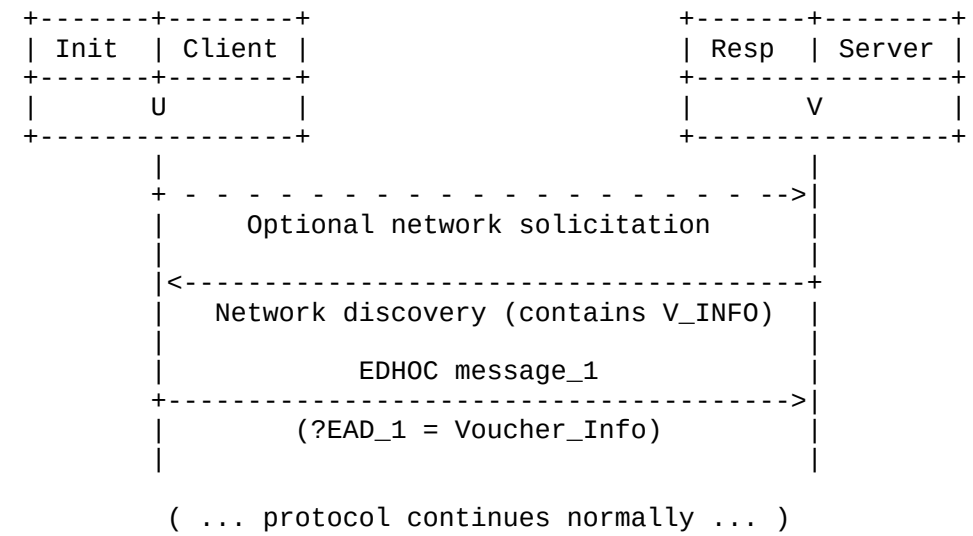

Figure 8: Advertising ELA using V_INFO in network-layer beacons.

This strategy can be used, for example, in IEEE 802.15.4, where an Enhanced Beacon [IEEE802.15.4] can be used to transmit V_INFO. Specifically, a new information element for carrying V_INFO can be defined according to [RFC8137].

This approach has the advantage of requiring minimal changes to the default protocol as presented in Section 4.1, i.e., no reverse flow. It requires, however, some profiling of the lower layer beacons.

A.2.2. V_INFO in EAD_1

The ELA reverse flow (see Section 4.8) allows implementing advertising where U first sends a trigger packet, in the format of a CoAP request that is broadcasted to the newtork. When a suitable V receives the solicitation, if it implements ELA, it should respond with an EDHOC message_1 whose EAD_1 has label TBD1 and value V_INFO (see Section Appendix A).

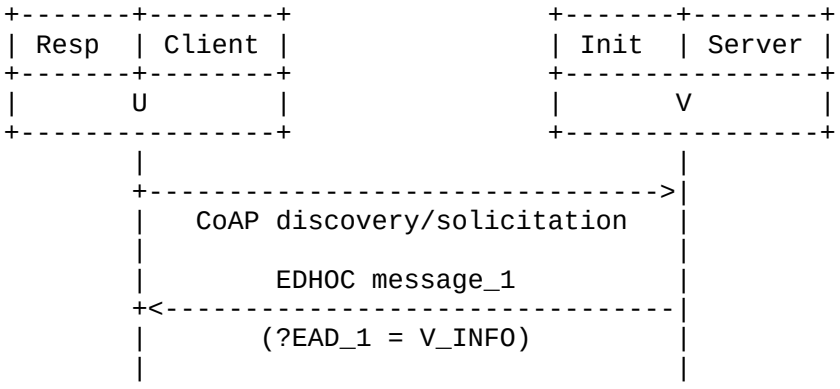

Figure 9: Advertising ELA using V_INFO in EAD_1, eploying the EDHOC reverse flow with U as responder.

Note that V will only reply if it supports ELA. V_INFO can be structured to contain only an optional domain identifier:

```
V_INFO = (
  ?DOMAIN_ID: bstr,
)
```

This approach enables a simple filtering mechanism, where only V's that support ELA will reply. It also encrypts Voucher_Info (as part of EAD_2), whereas it is sent in the clear in the original flow. In addition, it may not require layer-two profiling (in case the network allows transporting data before authorization). Finally, note that the reverse flow with U as Responder protects the identity of V (instead of U's as in the forward flow).

A.2.3. V_INFO in a CoAP Multicast Packet

In this approach, V periodically multicasts a CoAP packet containing V_INFO, see Figure 10. Upon receiving one or more CoAP messages and processing V_INFO, U can decide whether or not to initiate the ELA protocol with a given V. Next, the application can either keep U acting as a server, and thus employ the EDHOC reverse flow, or implement a CoAP client and use the forward flow.

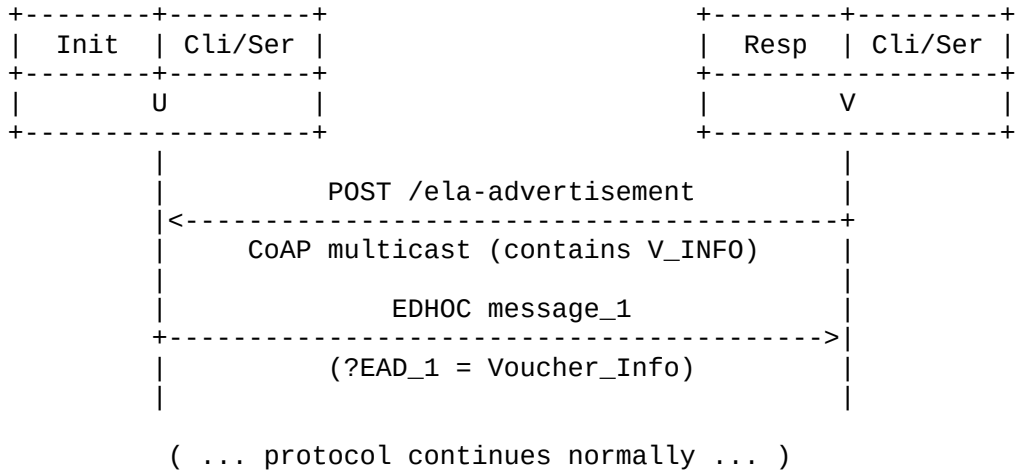

Figure 10: Advertising ELA using the network layer.

The V_INFO structure is sent as part of the CoAP payload. It is encoded as a CBOR sequence:

```
V_INFO = (
  ?DOMAIN_ID: bstr,
)
```

One advantage of this approach is that, since U is the initiator, its identity is protected in the context of the EDHOC handshake. On the other hand, the periodic multicast may have resource usage impacts in the network.

Appendix B. Use with Constrained Join Protocol (CoJP)

This section outlines how ELA is used for network enrollment and parameter provisioning. An IEEE 802.15.4 network is used as an example of how a new device (U) can be enrolled into the domain managed by the domain authenticator (V).

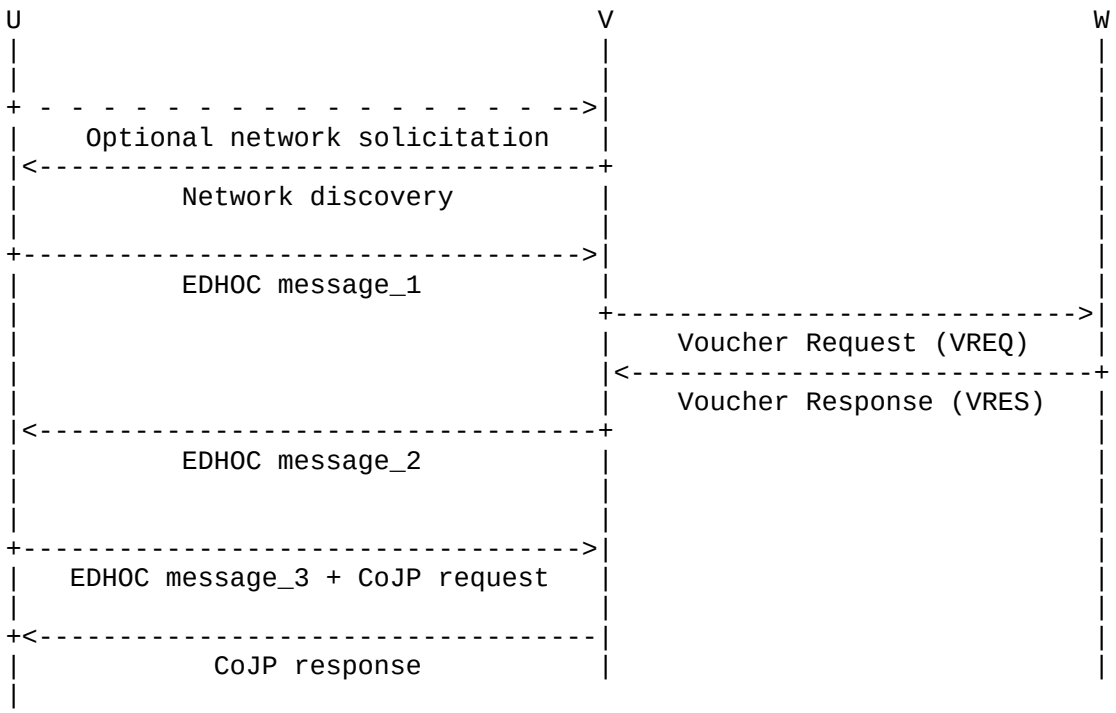

Figure 11: Use of draft-ietf-lake-authz with CoJP.

B.1. Network Discovery

When a device first boots, it needs to discover the network it attempts to join. The network discovery procedure is defined by the link-layer technology in use. In case of Time-slotted Channel Hopping (TSCH) networks, a mode of [IEEE802.15.4], the device scans the radio channels for Enhanced Beacon (EB) frames, a procedure known as passive scan. EBs carry the information about the network, and particularly the network identifier. Based on the EB, the network identifier, the information pre-configured into the device, the device makes the decision on whether it should join the network advertised by the received EB frame. This process is described in Section 4.1 of [RFC9031]. In case of other, non-TSCH modes of IEEE 802.15.4, it is possible to use the active scan procedure and send solicitation frames. These solicitation frames trigger the nearest network coordinator to respond by emitting a beacon frame. The network coordinator emitting beacons may be multiple link-layer hops away from the domain authenticator (V), in which case it plays the role of a Join Proxy (see [RFC9031]). The Join Proxy does not participate in the protocol and acts as a transparent router between the device and the domain authenticator. For simplicity, Figure 11

illustrates the case when the device and the domain authenticator are a single hop away and can communicate directly.

B.2. The Enrollment Protocol with Parameter Provisioning

B.2.1. Flight 1

Once the device has discovered the network it wants to join, it constructs EDHOC message_1, as described in Section 4.5. The device SHALL map the message to a CoAP request:

* The request method is POST.

* The type is Confirmable (CON).

* The Proxy-Scheme option is set to "coap".

* The Uri-Host option is set to "lake-authz.arpa". This is an anycast type of identifier of the domain authenticator (V) that is resolved to its IPv6 address by the Join Proxy.

* By means of Uri-Path options, the Uri-Path is set to ".well-known/edhoc".

* The payload is the (true, EDHOC message_1) CBOR sequence, where EDHOC message_1 is constructed as defined in Section 4.5.

B.2.2. Flight 2

The domain authenticator receives message_1 and processes it as described in Section 4.5. The message triggers the exchange with the enrollment server, as described in Section 4.6. If the exchange between V and W completes successfully, the domain authenticator prepares EDHOC message_2, as described in Section 4.5. The authenticator SHALL map the message to a CoAP response:

* The response code is 2.04 Changed.

* The payload is the EDHOC message_2, as defined in Section 4.5.

B.2.3. Flight 3

The device receives EDHOC message_2 and processes it as described in Section 4.5. Upon successful processing of message_2, the device prepares flight 3, which is an OSCORE-protected CoJP request containing an EDHOC message_3, as described in [I-D.ietf-core-oscore-edhoc]. EDHOC message_3 is prepared as described in Section 4.5. The OSCORE-protected payload is the CoJP

Join Request object specified in Section 8.4.1 of [RFC9031]. OSCORE protection leverages the OSCORE Security Context derived from the EDHOC session, as specified in Appendix A of [RFC9528]. To that end, [I-D.ietf-core-oscore-edhoc] specifies that the Sender ID of the client (device) must be set to the connection identifier selected by the domain authenticator, C_R. OSCORE includes the Sender ID as the kid in the OSCORE option. The network identifier in the CoJP Join Request object is set to the network identifier obtained from the network discovery phase. In case of IEEE 802.15.4 networks, this is the PAN ID.

The device SHALL map the message to a CoAP request:

* The request method is POST.

* The type is Confirmable (CON).

* The Proxy-Scheme option is set to "coap".

* The Uri-Host option is set to "lake-authz.arpa".

* The Uri-Path option is set to ".well-known/edhoc".

* The EDHOC option [I-D.ietf-core-oscore-edhoc] is set and is empty.

* The payload is prepared as described in Section 3.2 of [I-D.ietf-core-oscore-edhoc], with EDHOC message_3 and the CoJP Join Request object as the OSCORE-protected payload.

Note that the OSCORE Sender IDs are derived from the connection identifiers of the EDHOC session. This is in contrast with [RFC9031] where ID Context of the OSCORE Security Context is set to the device identifier (pledge identifier). Since the device identity is exchanged during the EDHOC session, and the certificate of the device is communicated to the authenticator as part of the Voucher Response message, there is no need to transport the device identity in OSCORE messages. The authenticator playing the role of the [RFC9031] JRC obtains the device identity from the execution of the authorization protocol.

B.2.4. Flight 4

Flight 4 is the OSCORE response carrying CoJP response message. The message is processed as specified in Section 8.4.2 of [RFC9031].

Appendix C. Example of opaque_state

As per Section 4.3, V may act statelessly and transmit a opaque_state to W during the VREQ call. The example below contains an IPv4 address, a port number, and a timestamp, serialized as CBOR:

```
83             # array(3)
   84          # array(4)
      18 C0    # unsigned(192)
      18 A8    # unsigned(168)
      00       # unsigned(0)
      05       # unsigned(5)
   19 5A18     # unsigned(23064)
   1A 6867EEE4 # unsigned(1751641828)
```

The above plaintext state can be encrypted using COSE. Speficially, it is useful that the plaintext is not only encrypted but also authenticated. That can be achieved using COSE_Encrypt0 using an AEAD algorithm.

Appendix D. Examples of protocol execution

This section presents high level examples of the protocol execution.

Note: the examples below include samples of access policies used by W. These are provided for the sake of completeness only, since the authorization mechanism used by W is out of scope in this document.

D.1. Minimal

This is a simple example that demonstrates a successful execution of ELA.

Premises:

* device u1 has ID_U = key id = 14

* the access policy in W specifies, via a list of ID_U, that device u1 can enroll via any domain authenticator, i.e., the list contains ID_U = 14. In this case, the policy only specifies a restriction in terms of U, effectively allowing enrollment via any V.

Execution:

1. device u1 discovers a gateway (v1) and tries to enroll

2. gateway v1 identifies the zero-touch join attempt by checking that the label of EAD_1 = TBD1, and prepares a Voucher Request using the information contained in the value of EAD_1

3. upon receiving the request, W obtains ID_U = 14, authorizes the access, and replies with Voucher Response

D.2. Wrong gateway

In this example, a device u1 tries to enroll a domain via gateway v1, but W denies the request because the pairing (u1, v1) is not configured in its access policies.

This example also illustrates how the REJECT_INFO field of the EDHOC error Access Denied could be used, in this case to suggest that the device should select another gateway for the join procedure.

Premises:

* devices and gateways communicate via Bluetooth Low Energy (BLE), therefore their network identifiers are MAC addresses (EUI-48)

* device u1 has ID_U = key id = 14

* there are 3 gateways in the radio range of u1:

  - v1 with MAC address = A2-A1-88-EE-97-75

  - v2 with MAC address = 28-0F-70-84-51-E4

  - v3 with MAC address = 39-63-C9-D0-5C-62

* the access policy in W specifies, via a mapping of shape (ID_U; MAC1, MAC2, ...) that device u1 can only join via gateway v3, i.e., the mapping is: (14; 39-63-C9-D0-5C-62)

* W is able to map the PoP key of the gateways to their respective MAC addresses

Execution:

1. device u1 tries to join via gateway v1, which forwards the request to W

2. W determines that MAC address A2-A1-88-EE-97-75 is not in the access policy mapping, and replies with an error. The error_content has REJECT_TYPE = 1, and the plaintext OPAQUE_INFO (used to compute the encrypted REJECT_INFO) specifies a list of suggested gateways = [h'3963C9D05C62']. The single element in the list is the 6-byte MAC address of v3, serialized as a bstr.

3. gateway v1 assembles an EDHOC error "Access Denied" with error_content, and sends it to u1

4. device u1 processes the error, decrypts REJECT_INFO, and retries the protocol via gateway v3

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