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F. Palombini
Ericsson
M. Tiloca
R. Höglund
RISE AB
S. Hristozov
Fraunhofer AISEC
G. Selander
Ericsson
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Using Ephemeral Diffie-Hellman Over COSE (EDHOC) with the Constrained
Application Protocol (CoAP) and Object Security for Constrained RESTful
Environments (OSCORE)
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Abstract

The lightweight authenticated key exchange protocol Ephemeral Diffie-Hellman Over COSE (EDHOC) can be run over the Constrained Application Protocol (CoAP) and used by two peers to establish a Security Context for the security protocol Object Security for Constrained RESTful Environments (OSCORE). This document details this use of the EDHOC protocol, by specifying a number of additional and optional mechanisms. These especially include an optimization approach for combining the execution of EDHOC with the first OSCORE transaction. This combination reduces the number of round trips required to set up an OSCORE Security Context and to complete an OSCORE transaction using that Security Context.

Discussion Venues

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

Discussion of this document takes place on the Constrained RESTful Environments Working Group mailing list (core@ietf.org), which is archived at <https://mailarchive.ietf.org/arch/browse/core/>.

Source for this draft and an issue tracker can be found at <https://github.com/core-wg/oscore-edhoc>.

Status of This Memo

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1. Introduction

Ephemeral Diffie-Hellman Over COSE (EDHOC) [RFC9528] is a lightweight authenticated key exchange protocol, especially intended for use in constrained scenarios. In particular, EDHOC messages can be transported over the Constrained Application Protocol (CoAP) [RFC7252] and used for establishing a Security Context for Object Security for Constrained RESTful Environments (OSCORE) [RFC8613].

This document details the use of the EDHOC protocol with CoAP and OSCORE, and specifies a number of additional and optional mechanisms. These especially include an optimization approach that combines the EDHOC execution with the first OSCORE transaction (see Section 3). This allows for a minimum number of two round trips necessary to setup the OSCORE Security Context and complete an OSCORE transaction, e.g., when an IoT device gets configured in a network for the first time.

This optimization is desirable, since the number of message exchanges can have a substantial impact on the latency of conveying the first OSCORE request, when using certain radio technologies.

Without this optimization, it is not possible to achieve the minimum number of two round trips. This optimization makes it possible, since the message_3 of the EDHOC protocol can be made relatively small (see Section 1.2 of [RFC9528]), thus allowing additional OSCORE-protected CoAP data within target MTU sizes.

The minimum number of two round trips can be achieved only if the default, forward message flow of EDHOC is used, i.e., when a CoAP client acts as EDHOC Initiator and a CoAP server acts as EDHOC Responder. The performance advantage of using this optimization can be lost when used in combination with Block-wise transfers [RFC7959] that rely on specific parameter values and block sizes.

Furthermore, this document defines a number of parameters corresponding to different information elements of an EDHOC application profile (see Section 6). These can be specified as target attributes in the link to an EDHOC resource associated with that application profile, thus enabling an enhanced discovery of such a resource for CoAP clients.

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.

The reader is expected to be familiar with terms and concepts defined in CoAP [RFC7252], CBOR [RFC8949], OSCORE [RFC8613], and EDHOC [RFC9528].

2. EDHOC Overview

This section is not normative and summarizes what is specified in [RFC9528], in particular its Appendix A.2. Thus, it provides a baseline for the enhancements in the subsequent sections.

The EDHOC protocol specified in [RFC9528] allows two peers to agree on a cryptographic secret, in a mutually-authenticated way and by using Diffie-Hellman ephemeral keys to achieve forward secrecy. The two peers are denoted as Initiator and Responder, as the one sending or receiving the initial EDHOC message_1, respectively.

After successful processing of EDHOC message_3, both peers agree on a cryptographic secret that can be used to derive further security material, and especially to establish an OSCORE Security Context [RFC8613]. The Responder can also send an optional EDHOC message_4 to achieve key confirmation, e.g., in deployments where no protected application message is sent from the Responder to the Initiator.

Appendix A.2 of [RFC9528] specifies how to transfer EDHOC over CoAP. That is, the EDHOC data (i.e., the EDHOC message possibly with a prepended connection identifier) are transported in the payload of CoAP requests and responses. The default, forward message flow of EDHOC consists in the CoAP client acting as Initiator and the CoAP server acting as Responder (see Appendix A.2.1 of [RFC9528]). Alternatively, the two roles can be reversed, as per the reverse message flow of EDHOC (see Appendix A.2.2 of [RFC9528]). In the rest of this document, EDHOC messages are considered to be transferred over CoAP.

Figure 1 shows a successful execution of EDHOC, with a CoAP client and a CoAP server running EDHOC as Initiator and Responder, respectively. In particular, it extends Figure 10 from Appendix A.2.1 of [RFC9528], by highlighting when the two peers perform EDHOC verification and establish the OSCORE Security Context, and by adding an exchange of OSCORE-protected CoAP messages after completing the EDHOC execution.

That is, the client sends a POST request to a reserved `_EDHOC` resource_ at the server, by default at the Uri-Path `"/.well-known/edhoc"`. The request payload consists of the CBOR simple value `true` (0xf5) concatenated with EDHOC message_1, which also includes the EDHOC connection identifier `C_I` of the client encoded as per Section 3.3 of [RFC9528]. The request has Content-Format `application/cid-edhoc+cbor-seq`.

This triggers the EDHOC execution at the server, which replies with a 2.04 (Changed) response. The response payload consists of EDHOC message_2, which also includes the EDHOC connection identifier `C_R` of the server encoded as per Section 3.3 of [RFC9528]. The response has Content-Format `application/edhoc+cbor-seq`.

Finally, the client sends a POST request to the same EDHOC resource used earlier when it sent EDHOC message_1. The request payload consists of the EDHOC connection identifier `C_R` encoded as per Section 3.3 of [RFC9528], concatenated with EDHOC message_3. The request has Content-Format `application/cid-edhoc+cbor-seq`.

After this exchange takes place, and after successful verifications as specified in the EDHOC protocol, the client and server can derive an OSCORE Security Context, as defined in Appendix A.1 of [RFC9528]. After that, they can use OSCORE to protect their communications as per [RFC8613]. Note that the EDHOC Connection Identifier C_R is used as the OSCORE Sender ID of the client (see Appendix A.1 of [RFC9528]). Therefore, C_R is transported in the 'kid' field of the OSCORE Option of the OSCORE Request (see Section 6.1 of [RFC8613]).

The client and server are required to agree in advance on certain information and parameters describing how they should use EDHOC. These are specified in an application profile associated with the EDHOC resource addressed (see Section 3.9 of [RFC9528]).

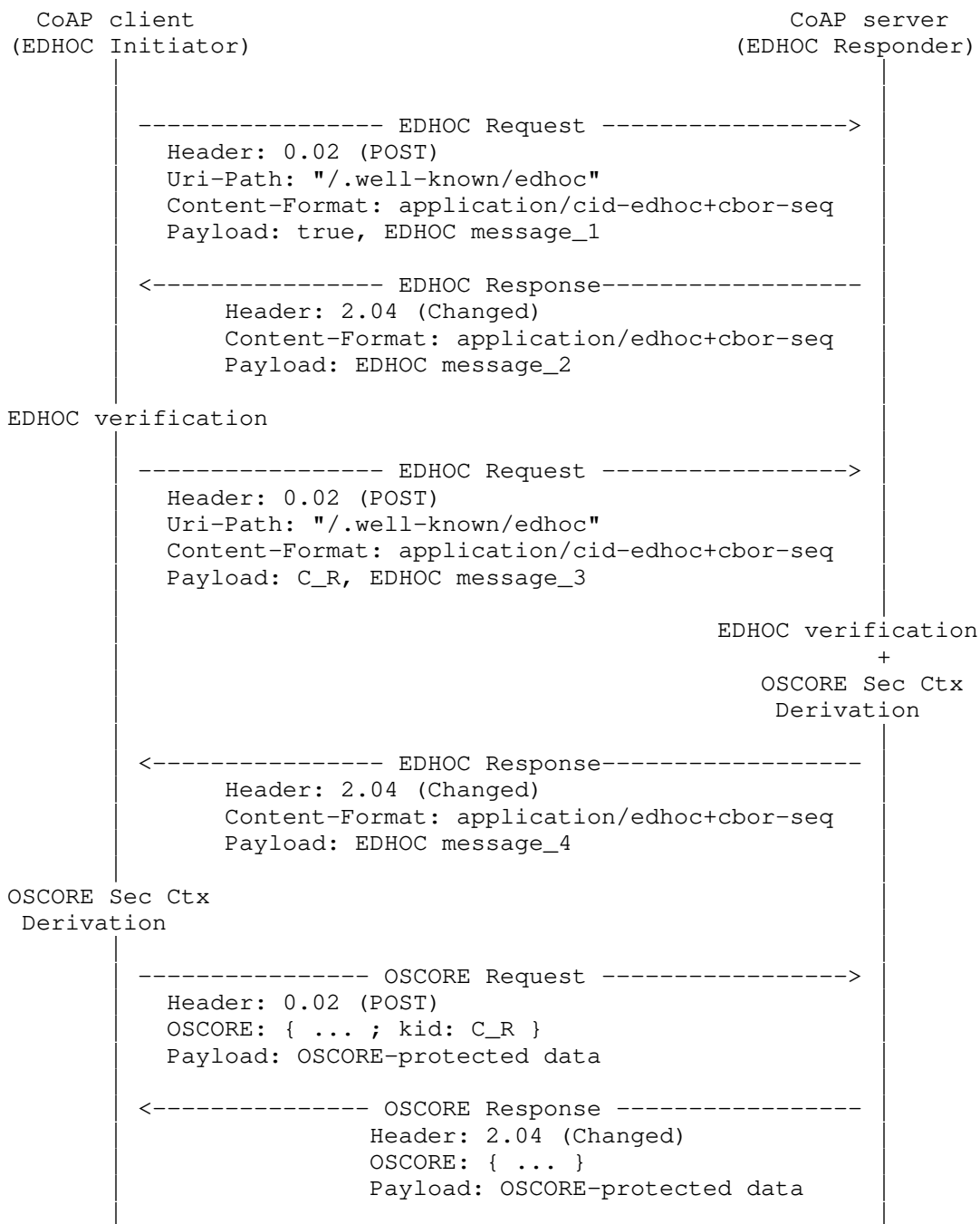


Figure 1: EDHOC and OSCORE run sequentially. The optional message_4 is included in this example.

As shown in Figure 1, this sequential flow where EDHOC is run first and then OSCORE is used takes three round trips to complete.

Section 3 defines an optimization for combining EDHOC with the first OSCORE transaction. This reduces the number of round trips required to set up an OSCORE Security Context and to complete an OSCORE transaction using that Security Context.

3. EDHOC Combined with OSCORE

This section defines an optimization for combining the EDHOC message exchange with the first OSCORE transaction, thus minimizing the number of round trips between the two peers to the absolute possible minimum of two round trips.

To this end, this approach can be used only if the default, forward message flow of EDHOC is used, i.e., when the client acts as Initiator and the server acts as Responder. The same is not possible in the case with reversed roles as per the reverse message flow of EDHOC.

When running the sequential flow of Section 2, the client has all the information to derive the OSCORE Security Context already after receiving EDHOC message_2 and before sending EDHOC message_3.

Hence, the client can potentially send both EDHOC message_3 and the subsequent OSCORE Request at the same time. On a semantic level, this requires sending two REST requests at once, as in Figure 2.

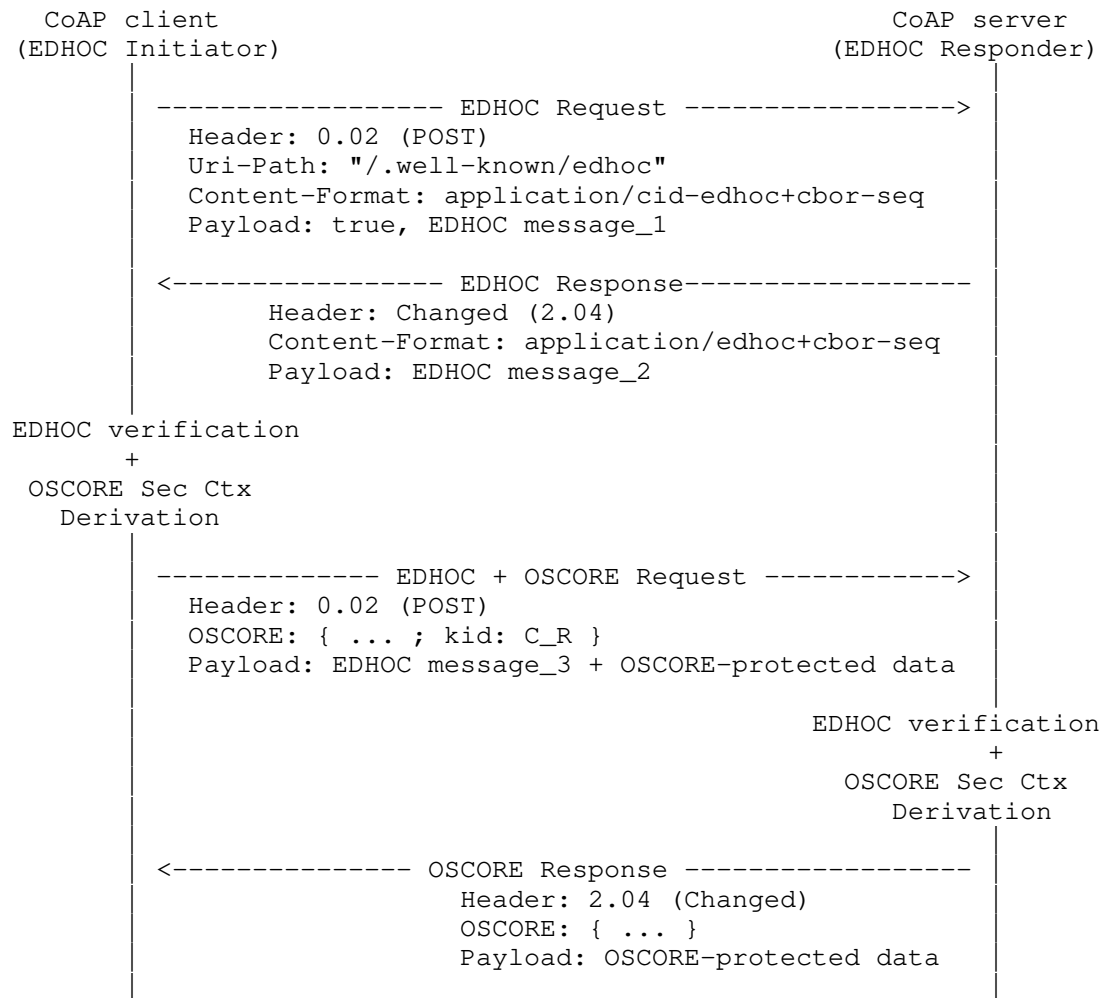


Figure 2: EDHOC and OSCORE combined.

To this end, the specific approach defined in this section consists of sending a single EDHOC + OSCORE request, which conveys the pair (C_R, EDHOC message_3) within an OSCORE-protected CoAP message.

That is, the EDHOC + OSCORE request is composed of the following two parts combined together in a single CoAP message. The steps for processing the EDHOC + OSCORE request and the two parts combined in there are defined in Section 3.2.1 and Section 3.3.1.

- * The OSCORE Request from Figure 1, which is also in this case sent to a protected resource, with the correct CoAP method and options intended for accessing that resource.
- * EDHOC data consisting of the pair (C_R, EDHOC message_3) required for completing the EDHOC session, transported as follows:
 - C_R is the OSCORE Sender ID of the client and hence transported in the 'kid' field of the OSCORE Option (see Section 6.1 of [RFC8613]). Unlike in the sequential workflow shown in Figure 1, C_R is thus not transported in the payload of the EDHOC + OSCORE request.
 - EDHOC message_3 is transported in the payload of the EDHOC + OSCORE request, prepended to the payload of the OSCORE Request. This is because EDHOC message_3 may be too large to be included in a CoAP Option, e.g., when conveying a large public key certificate chain as ID_CRED_I (see Section 3.5.3 of [RFC9528]) or when conveying large External Authorization Data as EAD_3 (see Section 3.8 of [RFC9528]).

The rest of this section specifies how to transport the data in the EDHOC + OSCORE request and their processing order. In particular, the use of this approach is explicitly signalled by including an EDHOC Option (see Section 3.1) in the EDHOC + OSCORE request. The processing of the EDHOC + OSCORE request is specified in Section 3.2 for the client side and in Section 3.3 for the server side.

3.1. EDHOC Option

This section defines the EDHOC Option. The option is used in a CoAP request, to signal that the request payload conveys both an EDHOC message_3 and OSCORE-protected data, combined together.

The EDHOC Option has the properties summarized in Table 1, which extends Table 4 of [RFC7252]. The option is Critical, Safe-to-Forward, and part of the Cache-Key. The option MUST occur at most once and MUST be empty. If any value is sent, the recipient MUST ignore it. (Future documents may update the definition of the option, by expanding its semantics and specifying admitted values.) The option is intended only for CoAP requests and is of Class U for OSCORE [RFC8613].

No.	C	U	N	R	Name	Format	Length	Default
21	x				EDHOC	Empty	0	(none)

Table 1: The EDHOC Option. C=Critical, U=Unsafe, N=NoCacheKey, R=Repeatable

The presence of this option means that the message payload also contains EDHOC data, which must be extracted and processed as defined in Section 3.3, before the rest of the message can be processed.

Figure 3 shows an example of a CoAP message transported over UDP and containing both the EDHOC data and the OSCORE ciphertext, using the newly defined EDHOC option for signalling.

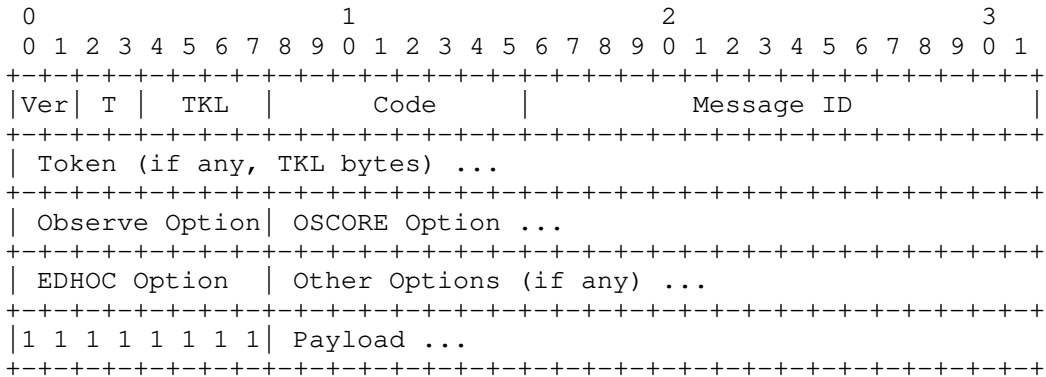


Figure 3: Example of CoAP message transported over UDP, combining EDHOC data and OSCORE data as signalled with the EDHOC Option.

3.2. Client Processing

This section describes the processing on the client side.

3.2.1. Processing of the EDHOC + OSCORE Request

The client prepares an EDHOC + OSCORE request as follows.

1. Compose EDHOC message_3 into EDHOC_MSG_3, as per Section 5.4.2 of [RFC9528].
2. Establish the new OSCORE Security Context and use it to encrypt the original CoAP request as per Section 8.1 of [RFC8613].

Note that the OSCORE ciphertext is not computed over EDHOC message_3, which is not protected by OSCORE. That is, the result of this step is the OSCORE Request as in Figure 1.

3. Build COMB_PAYLOAD as the concatenation of EDHOC_MSG_3 and OSCORE_PAYLOAD in this order: COMB_PAYLOAD = EDHOC_MSG_3 | OSCORE_PAYLOAD, where | denotes byte string concatenation and:
 - * EDHOC_MSG_3 is the binary encoding of EDHOC message_3 resulting from step 1. As per Section 5.4.1 of [RFC9528], EDHOC message_3 consists of one CBOR data item CIPHERTEXT_3, which is a CBOR byte string. Therefore, EDHOC_MSG_3 is the binary encoding of CIPHERTEXT_3.
 - * OSCORE_PAYLOAD is the OSCORE ciphertext of the OSCORE-protected CoAP request resulting from step 2.
4. Compose the EDHOC + OSCORE request, as the OSCORE-protected CoAP request resulting from step 2, where the payload is replaced with COMB_PAYLOAD built at step 3.

Note that the new payload includes EDHOC message_3, but it does not include the EDHOC connection identifier C_R. As the client is the EDHOC Initiator, C_R is the OSCORE Sender ID of the client, which is already specified as 'kid' in the OSCORE Option of the request from step 2, hence of the EDHOC + OSCORE request.

5. Include the new EDHOC Option defined in Section 3.1 into the EDHOC + OSCORE request.

The application/cid-edhoc+cbor-seq media type does not apply to this message, whose media type is unnamed.

6. Send the EDHOC + OSCORE request to the server.

With the same server, the client SHOULD NOT have multiple simultaneous outstanding interactions (see Section 4.7 of [RFC7252]) such that: they consist of an EDHOC + OSCORE request; and their EDHOC data pertain to the EDHOC session with the same connection identifier C_R.

(An exception might apply for clients that operate under particular time constraints over particularly unreliable networks, thus raising the chances to promptly complete the EDHOC execution with the server through multiple, simultaneous EDHOC + OSCORE requests. As discussed in Section 7, this does not have any impact in terms of security.)

3.2.2. Supporting Block-wise

If Block-wise [RFC7959] is supported, the client may fragment the first application CoAP request before protecting it as an original message with OSCORE, as defined in Section 4.1.3.4.1 of [RFC8613].

In such a case, the OSCORE processing in step 2 of Section 3.2.1 is performed on each inner block of the first application CoAP request, and the following also applies.

- * The client takes the additional following step between steps 2 and 3 of Section 3.2.1.

A. If the OSCORE-protected request from step 2 conveys a non-first inner block of the first application CoAP request (i.e., the Block1 Option processed at step 2 had NUM different than 0), then the client skips the following steps and sends the OSCORE-protected request to the server. In particular, the client **MUST NOT** include the EDHOC Option in the OSCORE-protected request.

- * The client takes the additional following step between steps 3 and 4 of Section 3.2.1.

B. If the size of COMB_PAYLOAD exceeds MAX_UNFRAGMENTED_SIZE (see Section 4.1.3.4.2 of [RFC8613]), the client **MUST** stop processing the request and **MUST** abandon the Block-wise transfer. Then, the client can continue by switching to the sequential workflow shown in Figure 1. That is, the client first sends EDHOC message_3 prepended by the EDHOC Connection Identifier C_R encoded as per Section 3.3 of [RFC9528], and then sends the OSCORE-protected CoAP request once the EDHOC execution is completed.

The performance advantage of using the EDHOC + OSCORE request can be lost when used in combination with Block-wise transfers that rely on specific parameter values and block sizes. Application policies at the CoAP client can define when and how to detect whether the performance advantage is lost, and, if that is the case, whether to appropriately adjust the parameter values and block sizes, or instead to fall back on the sequential workflow of EDHOC.

3.3. Server Processing

This section describes the processing on the server side.

3.3.1. Processing of the EDHOC + OSCORE Request

In order to process a request containing the EDHOC option, i.e., an EDHOC + OSCORE request, the server **MUST** perform the following steps.

1. Check that the EDHOC + OSCORE request includes the OSCORE option and that the request payload has the format defined at step 3 of Section 3.2.1 for COMB_PAYLOAD. If this is not the case, the server MUST stop processing the request and MUST reply with a 4.00 (Bad Request) error response.
2. Extract EDHOC message_3 from the payload COMB_PAYLOAD of the EDHOC + OSCORE request, as the first element EDHOC_MSG_3 (see step 3 of Section 3.2.1).
3. Take the value of 'kid' from the OSCORE option of the EDHOC + OSCORE request (i.e., the OSCORE Sender ID of the client), and use it as the EDHOC connection identifier C_R.
4. Retrieve the correct EDHOC session by using the connection identifier C_R from step 3.

If the application profile used in the EDHOC session specifies that EDHOC message_4 shall be sent, the server MUST stop the EDHOC processing and consider it failed, as due to a client error.

Otherwise, perform the EDHOC processing on the EDHOC message_3 extracted at step 2 as per Section 5.4.3 of [RFC9528], based on the protocol state of the retrieved EDHOC session.

The application profile used in the EDHOC session is the same one associated with the EDHOC resource where the server received the request conveying EDHOC message_1 that started the session. This is relevant in case the server provides multiple EDHOC resources, which may generally refer to different application profiles.

5. Establish a new OSCORE Security Context associated with the client as per Appendix A.1 of [RFC9528], using the EDHOC output from step 4.
6. Extract the OSCORE ciphertext from the payload COMB_PAYLOAD of the EDHOC + OSCORE request, as the second element OSCORE_PAYLOAD (see step 3 of Section 3.2.1).
7. Rebuild the OSCORE-protected CoAP request, as the EDHOC + OSCORE request where the payload is replaced with the OSCORE ciphertext extracted at step 6. Then, remove the EDHOC option.
8. Decrypt and verify the OSCORE-protected CoAP request rebuilt at step 7, as per Section 8.2 of [RFC8613], by using the OSCORE Security Context established at step 5.

When the decrypted request is checked for any critical CoAP options (as it is during regular CoAP processing), the presence of an EDHOC option MUST be regarded as an unprocessed critical option, unless it is processed by some further mechanism.

9. Deliver the CoAP request resulting from step 8 to the application.

If steps 4 (EDHOC processing) and 8 (OSCORE processing) are both successfully completed, the server MUST reply with an OSCORE-protected response (see Section 5.4.3 of [RFC9528]). The usage of EDHOC message_4 as defined in Section 5.5 of [RFC9528] is not applicable to the approach defined in this document.

If step 4 (EDHOC processing) fails, the server aborts the session as per Section 5.4.3 of [RFC9528] and responds with an EDHOC error message with error code 1, formatted as defined in Section 6.2 of [RFC9528]. The server MUST NOT establish a new OSCORE Security Context from the present EDHOC session with the client. The CoAP response conveying the EDHOC error message is not protected with OSCORE. As per Section 9.5 of [RFC9528], the server has to make sure that the error message does not reveal sensitive information. The CoAP response conveying the EDHOC error message MUST have Content-Format set to application/edhoc+cbor-seq registered in Section 10.9 of [RFC9528].

If step 4 (EDHOC processing) is successfully completed but step 8 (OSCORE processing) fails, the same OSCORE error handling as defined in Section 8.2 of [RFC8613] applies.

3.3.2. Supporting Block-wise

If Block-wise [RFC7959] is supported, the server takes the additional following step before any other in Section 3.3.1.

A. If Block-wise is present in the request, then process the Outer Block options according to [RFC7959], until all blocks of the request have been received (see Section 4.1.3.4 of [RFC8613]).

3.4. Example of EDHOC + OSCORE Request

Figure 4 shows an example of EDHOC + OSCORE Request transported over UDP. In particular, the example assumes that:

- * The OSCORE Partial IV in use is 0, consistently with the first request protected with the new OSCORE Security Context.
- * The OSCORE Sender ID of the client is 0x01.

As per Section 3.3.3 of [RFC9528], this straightforwardly corresponds to the EDHOC connection identifier C_R 0x01.

As per Section 3.3.2 of [RFC9528], when using the sequential flow shown in Figure 1, the same C_R with value 0x01 would be encoded on the wire as the CBOR integer 1 (0x01 in CBOR encoding), and prepended to EDHOC message_3 in the payload of the second EDHOC request.

- * The EDHOC option is registered with CoAP option number 21.

Note to RFC Editor: Please delete the last bullet point in the previous list, since, at the time of publication, the CoAP option number will be in fact registered.

This results in the following components shown in Figure 4:

- * OSCORE option value: 0x090001 (3 bytes)
- * EDHOC option value: - (0 bytes)
- * EDHOC message_3: 0x52d5535f3147e85f1cfacd9e78abf9e0a81bbf (19 bytes)
- * OSCORE ciphertext: 0x612f1092f1776f1c1668b3825e (13 bytes)

Protected CoAP request (OSCORE message):

```

0x44025dlf          ; CoAP 4-byte header
00003974            ; Token
93 090001           ; OSCORE Option
c0                  ; EDHOC Option
ff 52d5535f3147e85f1cfacd9e78abf9e0a81bbf
612f1092f1776f1c1668b3825e
(46 bytes)

```

Figure 4: Example of CoAP message transported over UDP, combining EDHOC data and OSCORE data as signalled with the EDHOC Option.

4. Use of EDHOC Connection Identifiers with OSCORE

The OSCORE Sender/Recipient IDs are the EDHOC connection identifiers (see Section 3.3.3 of [RFC9528]). This applies also to the optimized workflow defined in Section 3 of this document.

Note that, at step 3 of Section 3.3.1, the value of 'kid' in the OSCORE Option of the EDHOC + OSCORE request is both the server's Recipient ID (i.e., the client's Sender ID) and the EDHOC Connection Identifier C_R of the server.

4.1. Additional Processing of EDHOC Messages

When using EDHOC to establish an OSCORE Security Context, the client and server MUST perform the following additional steps during an EDHOC execution, thus extending Section 5 of [RFC9528].

4.1.1. Initiator Processing of Message 1

The Initiator selects an EDHOC Connection Identifier C_I as follows.

The Initiator MUST choose a C_I that is neither used in any current EDHOC session as this peer's EDHOC Connection Identifier, nor the Recipient ID in a current OSCORE Security Context where the ID Context is not present.

The chosen C_I SHOULD NOT be the Recipient ID of any current OSCORE Security Context. Note that, unless the two peers concurrently use alternative methods to establish OSCORE Security Contexts, this allows the Responder to always omit the 'kid context' in the OSCORE Option of its messages sent to the Initiator, when protecting those with an OSCORE Security Context where C_I is the Responder's OSCORE Sender ID (see Section 6.1 of [RFC8613]).

4.1.2. Responder Processing of Message 2

The Responder selects an EDHOC Connection Identifier C_R as follows.

The Responder MUST choose a C_R that is neither used in any current EDHOC session as this peer's EDHOC Connection Identifier, nor is equal to the EDHOC Connection Identifier C_I specified in the EDHOC message_1 of the present EDHOC session, nor is the Recipient ID in a current OSCORE Security Context where the ID Context is not present.

The chosen C_R SHOULD NOT be the Recipient ID of any current OSCORE Security Context. Note that, for a reason analogous to the one given above with C_I, this allows the Initiator to always omit the 'kid context' in the OSCORE Option of its messages sent to the Responder, when protecting those with an OSCORE Security Context where C_R is the Initiator's OSCORE Sender ID (see Section 6.1 of [RFC8613]).

4.1.3. Initiator Processing of Message 2

If the EDHOC Connection Identifier C_I is equal to the EDHOC Connection Identifier C_R specified in EDHOC message_2, then the Initiator MUST abort the session and reply with an EDHOC error message with error code 1, formatted as defined in Section 6.2 of [RFC9528].

5. Extension and Consistency of Application Profiles

It is possible to include the information below in the application profile referred by the client and server, according to the specified consistency rules.

If the server supports the EDHOC + OSCORE request within an EDHOC execution started at a certain EDHOC resource, then the application profile associated with that resource SHOULD explicitly specify support for the EDHOC + OSCORE request.

In case the application profile indicates that the server supports the optional EDHOC message_4 (see Section 5.5 of [RFC9528]), it is still possible to use the optimized workflow based on the EDHOC + OSCORE request. However, this means the server is not going to send EDHOC message_4, since it is not applicable to the optimized workflow (see Section 3.3.1).

Also, in case the application profile indicates that the server shall send EDHOC message_4, then the application profile MUST NOT specify support for the EDHOC + OSCORE request, and there is no point for the client to use the optimized workflow, which is bound to fail (see Section 3.3.1).

6. Web Linking

Section 10.10 of [RFC9528] registers the resource type "core.edhoc", which can be used as target attribute in a web link [RFC8288] to an EDHOC resource, e.g., using a link-format document [RFC6690]. This enables clients to discover the presence of EDHOC resources at a server, possibly using the resource type as filter criterion.

At the same time, the application profile associated with an EDHOC resource provides information describing how the EDHOC protocol can be used through that resource. A client may become aware of the application profile, e.g., by obtaining its information elements upon discovering the EDHOC resources at the server. This allows the client to discover especially the EDHOC resources whose associated application profile denotes a way of using EDHOC which is most suitable to the client, e.g., with EDHOC cipher suites or authentication methods that the client also supports or prefers.

That is, while discovering an EDHOC resource, a client can contextually obtain relevant pieces of information from the application profile associated with that resource. The resource discovery can occur by means of a direct interaction with the server, or instead by means of the CoRE Resource Directory [RFC9176], where the server may have registered the links to its resources.

In order to enable the above, this section defines a number of parameters, each of which can be optionally specified as a target attribute with the same name in the link to the respective EDHOC resource, or as filter criteria in a discovery request from the client. When specifying these parameters in a link to an EDHOC resource, the target attribute `rt="core.edhoc"` MUST be included, and the same consistency rules defined in Section 5 for the corresponding information elements of an application profile MUST be followed.

The following parameters are defined.

- * `'ed-i'`, specifying, if present, that the server supports the EDHOC Initiator role, hence the reverse message flow of EDHOC. A value MUST NOT be given to this parameter and any present value MUST be ignored by the recipient.
- * `'ed-r'`, specifying, if present, that the server supports the EDHOC Responder role, hence the forward message flow of EDHOC. A value MUST NOT be given to this parameter and any present value MUST be ignored by the recipient.
- * `'ed-method'`, specifying an authentication method supported by the server. This parameter MUST specify a single value, which is taken from the `'Value'` column of the "EDHOC Method Type" registry defined in Section 10.3 of [RFC9528]. This parameter MAY occur multiple times, with each occurrence specifying an authentication method.
- * `'ed-csuite'`, specifying an EDHOC cipher suite supported by the server. This parameter MUST specify a single value, which is taken from the `'Value'` column of the "EDHOC Cipher Suites"

registry defined in Section 10.2 of [RFC9528]. This parameter MAY occur multiple times, with each occurrence specifying a cipher suite.

- * 'ed-cred-t', specifying a type of authentication credential supported by the server. This parameter MUST specify a single value, which is taken from the 'Value' column of the "EDHOC Authentication Credential Types" Registry defined in Section 8.3 of this document. This parameter MAY occur multiple times, with each occurrence specifying a type of authentication credential.
- * 'ed-idcred-t', specifying a type of identifier supported by the server for identifying authentication credentials. This parameter MUST specify a single value, which is taken from the 'Label' column of the "COSE Header Parameters" registry [COSE.Header.Parameters]. This parameter MAY occur multiple times, with each occurrence specifying a type of identifier for authentication credentials.

Note that the values in the 'Label' column of the "COSE Header Parameters" registry are strongly typed. On the contrary, Link Format is weakly typed and thus does not distinguish between, for instance, the string value "-10" and the integer value -10. Thus, if responses in Link Format are returned, string values which look like an integer are not supported. Therefore, such values MUST NOT be used in the 'ed-idcred-t' parameter.

- * 'ed-ead', specifying the support of the server for an External Authorization Data (EAD) item (see Section 3.8 of [RFC9528]). This parameter MUST specify a single value, which is taken from the 'Label' column of the "EDHOC External Authorization Data" registry defined in Section 10.5 of [RFC9528]. This parameter MAY occur multiple times, with each occurrence specifying the ead_label of an EAD item that the server supports.
- * 'ed-comb-req', specifying, if present, that the server supports the EDHOC + OSCORE request defined in Section 3. A value MUST NOT be given to this parameter and any present value MUST be ignored by the recipient.

(Future documents may update the definition of the parameters 'ed-i', 'ed-r', and 'ed-comb-req', by expanding their semantics and specifying what they can take as value.)

The example in Figure 5 shows how a client discovers one EDHOC resource at a server, obtaining information elements from the respective application profile. The Link Format notation from Section 5 of [RFC6690] is used.

```
REQ: GET /.well-known/core

RES: 2.05 Content
    </sensors/temp>;osc,
    </sensors/light>;if=sensor,
    </.well-known/edhoc>;rt=core.edhoc;ed-csuite=0;ed-csuite=2;
    ed-method=0;ed-cred-t=1;ed-cred-t=3;ed-idcred-t=4;
    ed-i;ed-r;ed-comb-req
```

Figure 5: The Web Link.

7. Security Considerations

The same security considerations from OSCORE [RFC8613] and EDHOC [RFC9528] hold for this document. In addition, the following considerations also apply.

Section 3.2.1 specifies that a client SHOULD NOT have multiple outstanding EDHOC + OSCORE requests pertaining to the same EDHOC session. Even if a client did not fulfill this requirement, it would not have any impact in terms of security. That is, the server would still not process different instances of the same EDHOC message_3 more than once in the same EDHOC session (see Section 5.1 of [RFC9528]), and would still enforce replay protection of the OSCORE-protected request (see Sections 7.4 and 8.2 of [RFC8613]).

When using the optimized workflow in Figure 2, a minimum of 128-bit security against online brute force attacks is achieved after the client receives and successfully verifies the first OSCORE-protected response (see Sections 9.1 and 9.4 of [RFC9528]). As an example, if EDHOC is used with method 3 (see Section 3.2 of [RFC9528]) and cipher suite 2 (see Section 3.6 of [RFC9528]), then the following holds.

- * The Initiator is authenticated with 128-bit security against online attacks. As per Section 9.1 of [RFC9528], this results from the combination of the strength of the 64-bit MAC in EDHOC message_3 and of the 64-bit MAC in the AEAD of the first OSCORE-protected CoAP request, as rebuilt at step 7 of Section 3.3.1.
- * The Responder is authenticated with 128-bit security against online attacks. As per Section 9.1 of [RFC9528], this results from the combination of the strength of the 64-bit MAC in EDHOC message_2 and of the 64-bit MAC in the AEAD of the first OSCORE-protected CoAP response.

With reference to the sequential workflow in Figure 1, the OSCORE request might have to undergo access control checks at the server, before being actually executed for accessing the target protected resource. The same MUST hold when the optimized workflow in Figure 2 is used, i.e., when using the EDHOC + OSCORE request.

That is, the rebuilt OSCORE-protected application request from step 7 in Section 3.3.1 MUST undergo the same access control checks that would be performed on a traditional OSCORE-protected application request sent individually as shown in Figure 1.

To this end, validated information to perform access control checks (e.g., an access token issued by a trusted party) has to be available at the server before starting to process the rebuilt OSCORE-protected application request. Such information may have been provided to the server separately before starting the EDHOC execution altogether, or instead as External Authorization Data during the EDHOC execution (see Section 3.8 of [RFC9528]).

Thus, a successful completion of the EDHOC protocol and the following derivation of the OSCORE Security Context at the server do not play a role in determining whether the rebuilt OSCORE-protected request is authorized to access the target protected resource at the server.

8. IANA Considerations

This document has the following actions for IANA.

Note to RFC Editor: Please replace all occurrences of "[RFC-XXXX]" with the RFC number of this specification and delete this paragraph.

8.1. CoAP Option Numbers Registry

IANA is asked to enter the following option number to the "CoAP Option Numbers" registry within the "CoRE Parameters" registry group.

Number	Name	Reference
21	EDHOC	[RFC-XXXX]

Table 2: Registrations in
CoAP Option Numbers
Registry

Note to RFC Editor: Please delete this paragraph and all the following text within the present Section 8.1.

[

The CoAP option number 21 is consistent with the properties of the EDHOC Option defined in Section 3.1, and it allows the EDHOC Option to always result in an overall size of 1 byte. This is because:

- * The EDHOC option is always empty, i.e., with zero-length value; and
- * Since the OSCORE Option with option number 9 is always present in the EDHOC + OSCORE request, the EDHOC Option is encoded with a delta equal to at most 12.

Although the currently unassigned option number 13 would also work well for the same reasons in the use case in question, different use cases or protocols may make a better use of the option number 13. Hence the preference for the option number 21, and why it is not necessary to register additional option numbers than 21.

]

8.2. Target Attributes Registry

IANA is asked to register the following entries in the "Target Attributes" registry [CORE.Target.Attributes] within the "Constrained RESTful Environments (CoRE) Parameters" registry group, as per [I-D.ietf-core-target-attr]. For all entries, the Change Controller is IETF, and the reference is [RFC-XXXX].

Attribute Name:	Brief Description:
ed-i	Hint: support for the EDHOC Initiator role
ed-r	Hint: support for the EDHOC Responder role
ed-method	A supported authentication method for EDHOC
ed-csuite	A supported cipher suite for EDHOC
ed-cred-t	A supported type of authentication credential for EDHOC
ed-idcred-t	A supported type of authentication credential identifier for EDHOC
ed-ead	A supported External Authorization Data (EAD) item for EDHOC
ed-comb-req	Hint: support for the EDHOC+OSCORE request

Table 3: Registrations in Target Attributes Registry

8.3. EDHOC Authentication Credential Types Registry

IANA is requested to create a new "EDHOC Authentication Credential Types" registry within the "Ephemeral Diffie-Hellman Over COSE (EDHOC)" registry group defined in [RFC9528].

As registration policy, the registry uses either "Standards Action with Expert Review", or "Specification Required" per Section 4.6 of [RFC8126]. Expert Review guidelines are provided in Section 8.4.

All assignments according to "Standards Action with Expert Review" are made on a "Standards Action" basis per Section 4.9 of [RFC8126], with Expert Review additionally required per Section 4.5 of [RFC8126]. The procedure for early IANA allocation of Standards Track code points defined in [RFC7120] also applies. When such a procedure is used, review and approval by the designated expert are also required, in order for the WG chairs to determine that the conditions for early allocation are met (see step 2 in Section 3.1 of [RFC7120]).

The columns of this registry are:

- * **Value:** This field contains the value used to identify the type of authentication credential. These values MUST be unique. The value can be an unsigned integer or a negative integer, in the range from -65536 to 65535. Different ranges of values use different registration policies [RFC8126]:
 - Integer values from -24 to 23 are designated as "Standards Action With Expert Review".
 - Integer values from -65536 to -25 and from 24 to 65535 are designated as "Specification Required".
 - Integer values smaller than -65536 and greater than 65535 are marked as "Private Use".
- * **Description:** This field contains a short description of the type of authentication credential.
- * **Reference:** This field contains a pointer to the public specification for the type of authentication credential.

Initial entries in this registry are as listed in Table 4.

Value	Description	Reference
0	CBOR Web Token (CWT) containing a COSE_Key in a 'cnf' claim and possibly other claims. CWT is defined in RFC 8392.	[RFC8392]
1	CWT Claims Set (CCS) containing a COSE_Key in a 'cnf' claim and possibly other claims. CCS is defined in RFC 8392.	[RFC8392]
2	X.509 certificate	[RFC5280]

Table 4: Initial Entries in the "EDHOC Authentication Credential Types" Registry

8.4. Expert Review Instructions

The IANA registry established in this document is defined as "Standards Action with Expert Review" or "Specification Required", depending on the range of values for which an assignment is requested. This section gives some general guidelines for what the experts should be looking for; but they are being designated as experts for a reason, so they should be given substantial latitude.

Expert reviewers should take into consideration the following points:

- * Clarity and correctness of registrations. Experts are expected to check the clarity of purpose and use of the requested entries. Experts need to make sure that registered identifiers indicate a type of authentication credential whose format and encoding is clearly defined in the corresponding specification. Identifiers of types of authentication credentials that do not meet these objective of clarity and completeness must not be registered.
- * Point squatting should be discouraged. Reviewers are encouraged to get sufficient information for registration requests to ensure that the usage is not going to duplicate one that is already registered and that the point is likely to be used in deployments. The zones tagged as "Private Use" are intended for testing purposes and closed environments. Code points in other ranges should not be assigned for testing.
- * Specifications are required for the "Standards Action With Expert Review" range of point assignment. Specifications should exist for "Specification Required" ranges, but early assignment before a specification is available is considered to be permissible. When specifications are not provided, the description provided needs to have sufficient information to identify what the point is being used for.
- * Experts should take into account the expected usage of fields when approving point assignment. The fact that there is a range for Standards Track documents does not mean that a Standards Track document cannot have points assigned outside of that range. The length of the encoded value should be weighed against how many code points of that length are left, the size of device it will be used on, and the number of code points left that encode to that size.

9. References

9.1. Normative References

[CORE.Target.Attributes]
IANA, "Target Attributes",
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[COSE.Header.Parameters]
IANA, "COSE Header Parameters",
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9.2. Informative References

- [I-D.ietf-core-target-attr]
Bormann, C., "CoRE Target Attributes Registry", Work in Progress, Internet-Draft, draft-ietf-core-target-attr-06, 11 October 2023, <<https://datatracker.ietf.org/doc/html/draft-ietf-core-target-attr-06>>.

Appendix A. Document Updates

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

A.1. Version -10 to -11

- * Avoid using quotation marks for CBOR Simple Values.
- * Early mentioning of the optimization properties.
- * Less entries of new IANA registry; made their references normative.
- * Clarified meaning of "Standards Action with Expert Review" policy.
- * Clarifications, simplified phrasing, and editorial improvements.
- * Updated references.

A.2. Version -09 to -10

- * Expanded acronyms in the document title.
- * Clarified transport of EDHOC C_R and EDHOC message_3.
- * Simplified text on the use of EDHOC Connection Identifiers as OSCORE Identifiers.
- * Added the CoAP OSCORE Option in the figures of the EDHOC message flows.
- * Added more pointers to the message processing, now defined in dedicated subsections.
- * Detecting and preventing a loss of performance advantage when using Block-wise transfers is for application policies to specify.
- * Clarified use of EDHOC application profiles.
- * Clarified security considerations on the achieved security level.
- * Fixes and editorial improvements.

A.3. Version -08 to -09

- * Clarified meaning of "EDHOC data".
- * Improved description of entries for the new IANA registry.
- * Change Controller changed from "IESG" to "IETF".
- * Editorial: EDHOC Option number denoted as "21" instead of "TBD21".
- * Fixed references to sections of draft-ietf-lake-edhoc
- * Clarifications and editorial improvements.

A.4. Version -07 to -08

- * Fixes and clarifications from the Shepherd's review.

A.5. Version -06 to -07

- * Changed document title.

- * The client creates the OSCORE Security Context after creating EDHOC message_3.
- * Revised selection of EDHOC connection identifiers.
- * Use of "forward message flow" and "reverse message flow".
- * The payload of the combined request is not a CBOR sequence anymore.
- * EDHOC error messages from the server are not protected with OSCORE.
- * More future-proof error handling on the server side.
- * Target attribute names prefixed by "ed-".
- * Defined new target attributes "ed-i" and "ed-r".
- * Defined single target attribute "ed-ead" signaling supported EAD items.
- * Security consideration on the minimally achieved 128-bit security.
- * Defined and used the "EDHOC Authentication Credential Types" Registry.
- * High-level sentence replacing the appendix on Block-wise performance.
- * Revised examples.
- * Editorial improvements.

A.6. Version -05 to -06

- * Extended figure on EDHOC sequential workflow.
- * Revised naming of target attributes.
- * Clarified semantics of target attributes 'eadx'.
- * Registration of target attributes.

A.7. Version -04 to -05

- * Clarifications on Web Linking parameters.

- * Added security considerations.
- * Revised IANA considerations to focus on the CoAP option number 21.
- * Guidelines on using Block-wise moved to an appendix.
- * Editorial improvements.

A.8. Version -03 to -04

- * Renamed "applicability statement" to "application profile".
- * Use the latest Content-Formats.
- * Use of SHOULD NOT for multiple simultaneous outstanding interactions.
- * No more special conversion from OSCORE ID to EDHOC ID.
- * Considerations on using Block-wise.
- * Web Linking signaling of multiple supported EAD labels.
- * Added security considerations.
- * Editorial improvements.

A.9. Version -02 to -03

- * Clarifications on transporting EDHOC message_3 in the CoAP payload.
- * At most one simultaneous outstanding interaction as an EDHOC + OSCORE request with the same server for the same session with connection identifier C_R.
- * The EDHOC option is removed from the EDHOC + OSCORE request after processing the EDHOC data.
- * Added explicit constraints when selecting a Recipient ID as C_X.
- * Added processing steps for when Block-wise is used.
- * Improved error handling on the server.
- * Improved section on Web Linking.
- * Updated figures; editorial improvements.

A.10. Version -01 to -02

- * New title, abstract and introduction.
- * Restructured table of content.
- * Alignment with latest format of EDHOC messages.
- * Guideline on ID conversions based on application profile.
- * Clarifications, extension and consistency on application profile.
- * Section on web-linking.
- * RFC8126 terminology in IANA considerations.
- * Revised Appendix "Checking CBOR Encoding of Numeric Values".

A.11. Version -00 to -01

- * Improved background overview of EDHOC.
- * Added explicit rules for converting OSCORE Sender/Recipient IDs to EDHOC connection identifiers following the removal of bstr_identifier from EDHOC.
- * Revised section organization.
- * Recommended number for EDHOC option changed to 21.
- * Editorial improvements.

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Authors' Addresses

Francesca Palombini
Ericsson
Email: francesca.palombini@ericsson.com

Marco Tiloca
RISE AB
Isafjordsgatan 22
SE-16440 Stockholm Kista
Sweden
Email: marco.tiloca@ri.se

Rikard Höglund
RISE AB
Isafjordsgatan 22
SE-16440 Stockholm Kista
Sweden
Email: rikard.hoglund@ri.se

Stefan Hristozov
Fraunhofer AISEC
Email: stefan.hristozov@eriptic.com

Göran Selander
Ericsson
Email: goran.selander@ericsson.com