Key Update for OSCORE (KUDOS)

draft-ietf-core-oscore-key-update-02

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Content Recap

- OSCORE (RFC8613) uses AEAD algorithms to provide security
  - Need to follow limits in number of encryptions and failed decryptions, before rekeying
  - Excessive use of the same key can enable breaking security properties of the AEAD algorithm*

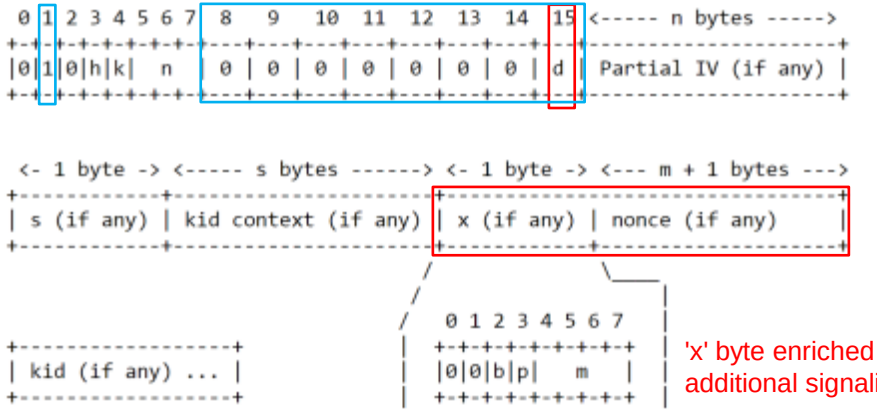
- (1) Defined Key Update for OSCORE (KUDOS) ⟵ FOCUS OF TODAY
  - Loosely inspired by Appendix B.2 of OSCORE
  - Goal: Renew the Master Secret and Master Salt; derive new Sender/Recipient keys from those
  - Can achieve Perfect Forward Secrecy

- (2) AEAD Key Usage Limits in OSCORE
  - Defining appropriate limits for OSCORE, for a variety of algorithms
  - Defining counters for key usage; message processing details; steps when limits are reached

*See also draft-irtf-cfrg-aead-limits

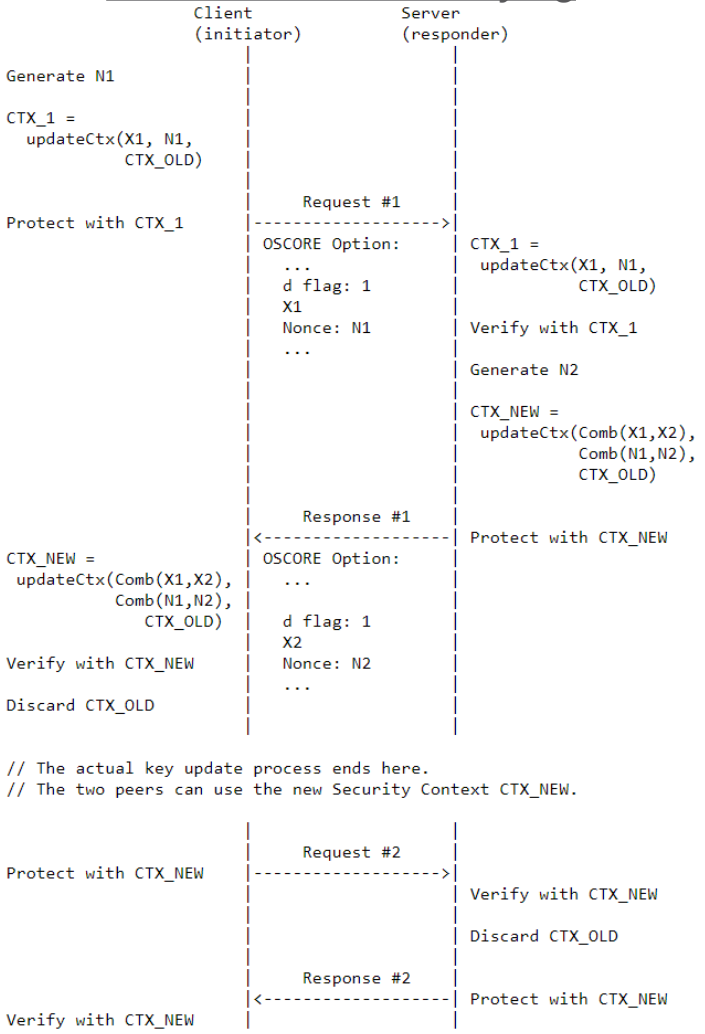
Key Update Recap

- Method for rekeying OSCORE
  - Key Update for OSCORE (KUDOS)
  - Client and server exchange nonces N1 and N2
  - *UpdateCtx()* function for deriving new OSCORE Security Context using the nonces
  - Extended OSCORE Option
    - IANA: can bits "1" and "15" be "1 (suggested)" and "15 (suggested)"? --> We do need and prefer exactly "1" and "15"
    - 'id detail' renamed to 'nonce'



'x' byte enriched with additional signaling flags

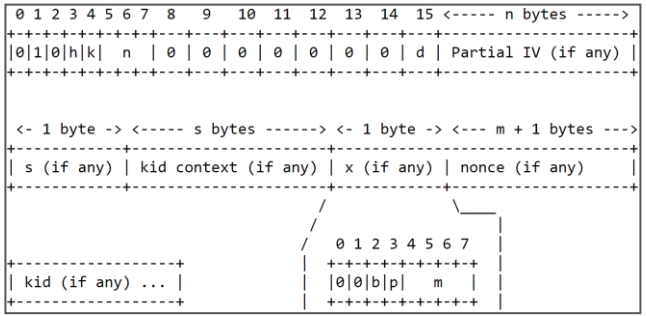
Client-initiated rekeying



Key Update without FS (1/2)

- Alternative KUDOS mode without Forward Secrecy
  - Text moved from old Appendix to document body and improved (Section 4.4)
  - Stateless key update; needed for devices that cannot store to persistent memory

- Signaling through a new 'p' bit in the 'x' byte of the OSCORE Option
  - 'p' set to 0 ==> sender's wish to run KUDOS in FS mode (original mode)
  - 'p' set to 1 ==> sender's wish to run KUDOS in no-FS mode
  - If p = 0 in both KUDOS messages ==> use the FS mode
  - If p = 1 in both KUDOS messages ==> use the no-FS mode



- When using the FS-mode
  - The latest Security Context CTX_OLD is used as is, and FS is preserved
  - Devices capable of writing to persistent memory should initiate the procedure with 'p' set to 0

Key Update without FS (2/2)

- When using the no-FS mode
  - FS is sacrificed due to at least one peer unable to write to persistent memory
  - Before starting KUDOS, the CTX_OLD is modified to ensure that:
    - Master Secret = Bootstrap Master Secret, and Master Salt = Bootstrap Master Salt.
  - Every execution of KUDOS between these peers will consider this same Secret/Salt pair

Bootstrap material
Pre-provisioned during manufacturing or (re-)commissioning

- Agreed downgrading to no-FS mode
  - If the initiator sets 'p' to 0, the responder might not follow-up (if unable to write to disk)
    - Server responder: return a protected 5.03 error response, with 'p' set to 1
    - Client responder: send a protected request, with 'p' set to 1
    - In either case, abort KUDOS
  - Then, the initiator may retry with 'p' set to 1

- Section 4.4.1 has an extensive discussion on handling keying material and reboot

Comments? Questions?

Preserving Observations (1/2)

› Content moved from old appendix to document body and extended (Section 4.5)

› Problem recap:

1. The client starts an observation Obs1 by sending a request Req1 with req_piv X
2. The two peers run KUDOS, and reset their Sender Sequence Number (SSN) to 0.
3. Later on, while Obs1 is still ongoing, the client sends a new request Req2 also with req_piv X. This is not necessarily an observation request.
4. A notification sent by the server for Obs1 and a response to Req2 would both cryptographically match against Req1 and Req2 by OSCORE external_aad.

› Solution: "Long-jumping" of OSCORE Sender Sequence Numbers (SSNs)

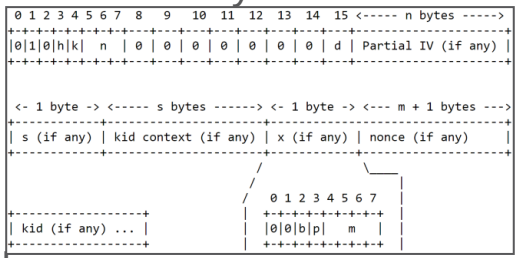
- After completing KUDOS, a peer determines PIV* as the highest req_piv among all the ongoing observations where it is client.
- The peer updates its SSN to be (PIV* + 1)

Preserving Observations (2/2)

- Signaling through a new 'b' bit in the 'x' byte of the OSCORE Option
  - 'p' set to 0 ==> sender's wish to cancel all common observations beyond key update
  - 'p' set to 1 ==> sender's wish to keep all common observations beyond key update

- Simple "all-or-nothing" approach
  - If p = 1 in both KUDOS messages, peers keep their observations, otherwise they are cancelled

- A client ever wishing to preserve its observations:
  - MUST NOT silently forget them
  - Has to use cancellation requests (Observe:1)
    - Observations are purged only if receiving a confirmation from the server



- Even though key update is not of interest at the present moment ...
  - A peer might run KUDOS to quickly cancel the ongoing observations with the other peer!

Comments? Questions?

Update of Sender/Recipient IDs

- Method for updating peers' OSCORE Sender/Recipient IDs
  - Based on earlier discussions on the mailing list [1][2] and on [3]
  - This procedure can be embedded in a KUDOS execution or run standalone
  - This procedure can be initiated by a client or by a server
  - Content moved from old appendix to document body and improved (Section 5)

No.	C	U	N	R	Name	Format	Length	Default
TBD1					Recipient-ID	opaque	0-7	(none)

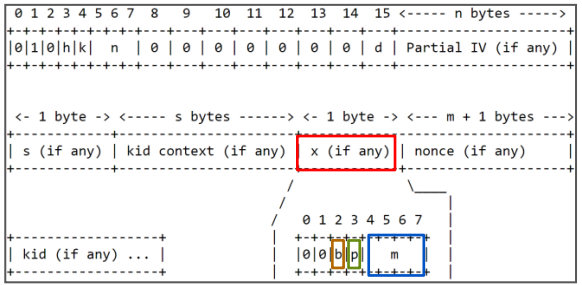
C=Critical, U=Unsafe, N=NoCacheKey, R=Repeatable

- Properties
  - The sender indicates its new wished Recipient ID in the new Recipient-ID Option (class E)
  - Both peers have to opt-in and agree in order for the IDs to be updated
  - Changing IDs practically triggers derivation of new OSCORE Security Context
  - Must not be done immediately following a reboot (e.g., KUDOS must be run first)
  - Offered Recipient ID must be not used yet under (Master Secret, Master Salt, ID Context)
  - Received Recipient ID must not be used yet as own Sender ID under the same triple
- Examples are provided in Sections 5.1.1 and 5.1.2

[1] https://mailarchive.ietf.org/arch/msg/core/GXsKO4wKdt3RTZnQZxOzRdIG9QI/
[2] https://mailarchive.ietf.org/arch/msg/core/ClwcSF0BUVxDas8BpgT0WY1yQrY/
[3] https://github.com/core-wg/oscore/issues/263#issue-946989659

Further Updates (1/2)

- Defined signaling bits present in the 'x' byte
  - Four least significant bits encode the 'nonce' length in bytes minus 1 (*length indication for 'nonce'*)
  - Fifth least significant bit is the "No Forward Secrecy" 'p' bit (*controls using FS or no-FS mode*)
  - Sixth least significant bit is the "Preserve Observations" 'b' bit (*controls preserving observations or not*)
  - The two most significant bits are reserved for now



- Redesigned the updateCtx() function
  - updateCtx(N, CTX_IN) --> updateCtx(X, N, CTX_IN)
    - 'x' bytes also as input --> Covered by key derivation --> Integrity protected
  - Still two available methods
    - METHOD 1: use EDHOC-KeyUpdate, if EDHOC was used to derive the first Ctx
    - METHOD 2: a simple plain use of HKDF-Expand(), if EDHOC was not used
  - When using METHOD 1
    - Aligned with the new EDHOC-KeyUpdate(), with input a CBOR byte string
    - Defined rules about when replacing the old EDHOC keys PRK_out and PRK_exporter

Further Updates (2/2)

- X1 and X2: raw value of 'x' in the OSCORE Option of 1st/2nd KUDOS message
- N1 and N2: raw value of 'nonce' in the OSCORE Option of 1st/2nd KUDOS message
- Before updateCtx(), blends the Xs and Ns into X and N
  - Message 1: X = X1 and N = N1
  - Message 2: X = bstr .cbor X1 | bstr .cbor X2 , N = bstr .cbor N1 | bstr .cbor N2
- Invoke updateCtx(X, N, ...), which blends X and N into a single CBOR byte string X_N
  - X_cbor = bstr .cbor X
  - N_cbor = bstr .cbor N
  - X_N = bstr .cbor (X_cbor | N_cbor)
  - X_N is used as input to EDHOC-KeyUpdate() or to HKDF-Expand()

Comments? Questions?

Open points & Next steps

- Continue addressing the issues on the Github repo [1]

- Proposal: reorganize/split updateCtx() into
  - A preamble to compute X_N and then invoke ...
  - … METHOD 1, based on EDHOC-KeyUpdate() or ...
  - … METHOD 2, based on HKDF-based

- Proposal: agreed fallback to METHOD 2
  - E.g., an EDHOC session is not valid anymore
  - New signaling bit in the 'x' byte to use when running KUDOS; same as when agreeing on no-FS

- Implementation built on existing implementation of OSCORE in Java based on Californium

- Comments and reviews are welcome!

```
if <the original Security Context was established through EDHOC> {
  // METHOD 1

  // Update the EDHOC key PRK_out, and use the
  // new one to update the EDHOC key PRK_exporter
  (new PRK_out, new PRK_exporter) = EDHOC-KeyUpdate(X_N)

  MSECRET_NEW = EDHOC-Exporter(0, h'', oscore_key_length)
    = EDHOC-KDF(new PRK_exporter, 0, h'', oscore_key_length)

  oscore_salt_length = < Size of CTX_IN.MasterSalt in bytes >

  MSALT_NEW = EDHOC-Exporter(1, h'', oscore_salt_length)
    = EDHOC-KDF(new PRK_exporter, 1, h'', oscore_salt_length)

}
else {
  // METHOD 2

  Label = "key update"

  MSECRET_NEW = HKDF-Expand-Label(CTX_IN.MasterSecret, Label,
                                  X_N, oscore_key_length)
              = HKDF-Expand(CTX_IN.MasterSecret, HkdfLabel,
                            oscore_key_length)

  MSALT_NEW = N;
}
```

[1] https://github.com/core-wg/oscore-key-update/issues

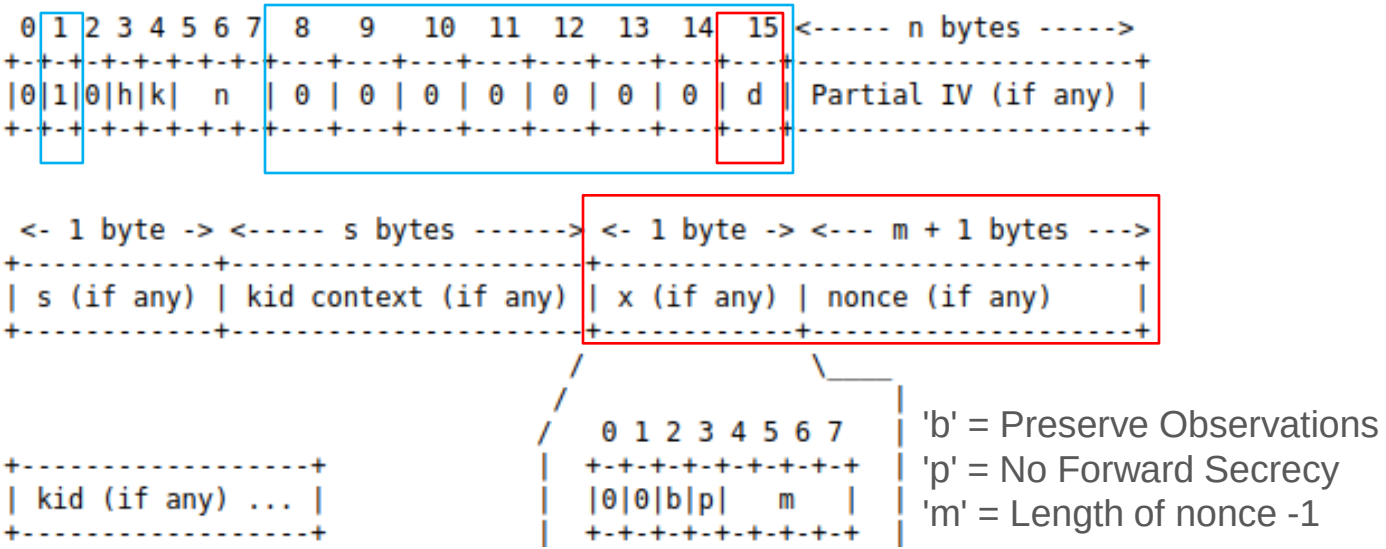
Thank you!

Comments/questions?

https://github.com/core-wg/oscore-key-update

OSCORE Option update

- OSCORE Option: defined the use of flag bit 1 to signal presence of flag bits 8-15
- Defined flag bit 15 -- 'd' -- to indicate:
  - This is a OSCORE key update message
  - "nonce" is specified (length + value); used to transport a nonce for the key update



Key limits (1/3)

Confidentiality Advantage (CA): Probability of breaking confidentiality properties

Integrity Advantage (IA): Probability of breaking integrity properties

- Recap on AEAD limits
  - Discussed in **draft-irtf-cfrg-aead-limits-03**
  - Limits key use for encryption (q) and invalid decryptions (v)
  - This draft defines fixed values for ‘q’, ‘v’, and ‘l’ and from those calculate CA & IA probabilities
    - IA & CA probabilities must be acceptably low
- Now explicit size limit of protected data to be sent in a new OSCORE message
  - The probabilities are influenced by ‘l’, i.e., maximum message size in cipher blocks
  - Implementations should not exceed 'l', and it has to be easy to avoid doing so
  - New text: *the total size of the COSE plaintext, authentication Tag, and possible cipher padding for a message may not exceed the block size for the selected algorithm multiplied with 'l‘*
- New table (Figure 3) showing values of ‘l’ not just in cipher blocks but actual bytes

Key limits (2/3)

- Increased value of ‘l’ (message size in blocks) for algos except AES_128_CCM_8
  - Increasing ‘l’ from 2^8 to 2^10 should maintain secure CA and IA probabilities
  - draft-irtf-cfrg-aead-limits mentions aiming for CA & IA lower than to 2^-50
    - They have added a table in that document with calculated ‘q’ and ‘v’ values

q = 2^20, v = 2^20, and l = 2^10

Algorithm name	IA probability	CA probability
AEAD_AES_128_CCM	2^-64	2^-66
AEAD_AES_128_GCM	2^-97	2^-89
AEAD_AES_256_GCM	2^-97	2^-89
AEAD_CHACHA20_POLY1305	2^-73	-

- Intent is to increase 'q', 'v' and/or 'l' further. Should we?
  - Since we are well below 2^-50 for CA & IA currently

Key limits (3/3)

- Updated table of ‘q’, ‘v’ and ‘l’ for AES_128_CCM_8
  - Added new value for ‘v’, still leaving CA and IA less than 2^-50
  - Is it ideal to aim for CA & IA close to 2^-50 as defined in the CRFG document?

'q', 'v' and 'l'	IA probability	CA probability
q=2^20, v=2^20, l=2^8	2^-44	2^-70
q=2^15, v=2^20, l=2^8	2^-44	2^-80
q=2^10, v=2^20, l=2^8	2^-44	2^-90
q=2^20, v=2^15, l=2^8	2^-49	2^-70
q=2^15, v=2^15, l=2^8	2^-49	2^-80
q=2^10, v=2^15, l=2^8	2^-49	2^-90
q=2^20, v=2^14, l=2^8	2^-50	2^-70
q=2^15, v=2^14, l=2^8	2^-50	2^-80
q=2^10, v=2^14, l=2^8	2^-50	2^-90
q=2^20, v=2^10, l=2^8	2^-54	2^-70
q=2^15, v=2^10, l=2^8	2^-54	2^-80
q=2^10, v=2^10, l=2^8	2^-54	2^-90

'q', 'v' and 'l'	IA probability	CA probability
q=2^20, v=2^20, l=2^6	2^-44	2^-74
q=2^15, v=2^20, l=2^6	2^-44	2^-84
q=2^10, v=2^20, l=2^6	2^-44	2^-94
q=2^20, v=2^15, l=2^6	2^-49	2^-74
q=2^15, v=2^15, l=2^6	2^-49	2^-84
q=2^10, v=2^15, l=2^6	2^-49	2^-94
q=2^20, v=2^14, l=2^6	2^-50	2^-74
q=2^15, v=2^14, l=2^6	2^-50	2^-84
q=2^10, v=2^14, l=2^6	2^-50	2^-94
q=2^20, v=2^10, l=2^6	2^-54	2^-74
q=2^15, v=2^10, l=2^6	2^-54	2^-84
q=2^10, v=2^10, l=2^6	2^-54	2^-94

Key update overview

- Defined a new method for rekeying OSCORE
  - Key Update for OSCORE (KUDOS)
  - Client and server exchange nonces N1 and N2
  - *UpdateCtx()* function for deriving new OSCORE Security Context using the nonces

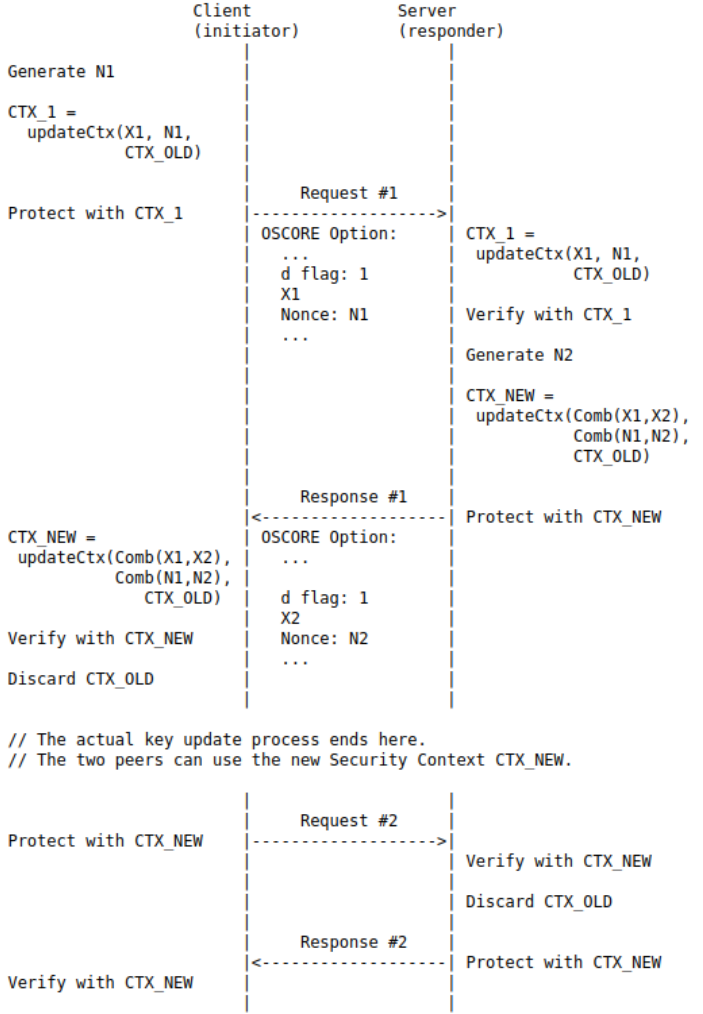
- Properties
  - Can be initiated by either the client or server
  - Completes in one round-trip (after that, the new Security Context can be used)
  - Only one intermediate Security Context is derived
  - The ID Context does not change
  - Robust and secure against peer rebooting
  - Compatible with prior key establishment using the EDHOC protocol

NEW - Mode with FS (stateful) and without FS (stateless)

NEW - Possibility to preserve ongoing observations

NEW - Possibility to update Recipient/Sender IDs

Client-initiated rekeying



“Long-Jumping”