Kemeleon:

Elligator-like Obfuscation for Post-Quantum Cryptography

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What about standardized post-quantum key exchanges — ML-KEM?

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- **Kemeleon Encoding**
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- OEINC: Obfuscated KEM Combiner
- Hybrid Applications:
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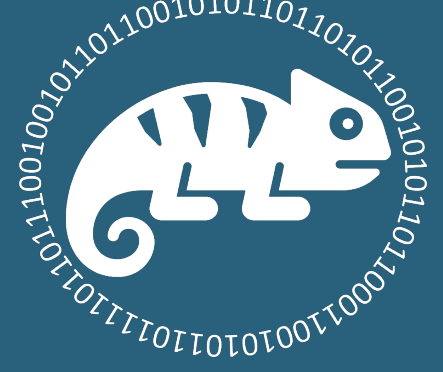

Byte Distribution of ML-KEM-768 Public Keys

ML-KEM public keys: Polynomials with coefficients mod q=3329, and a random seed

Image inspired by: Jack Wampler

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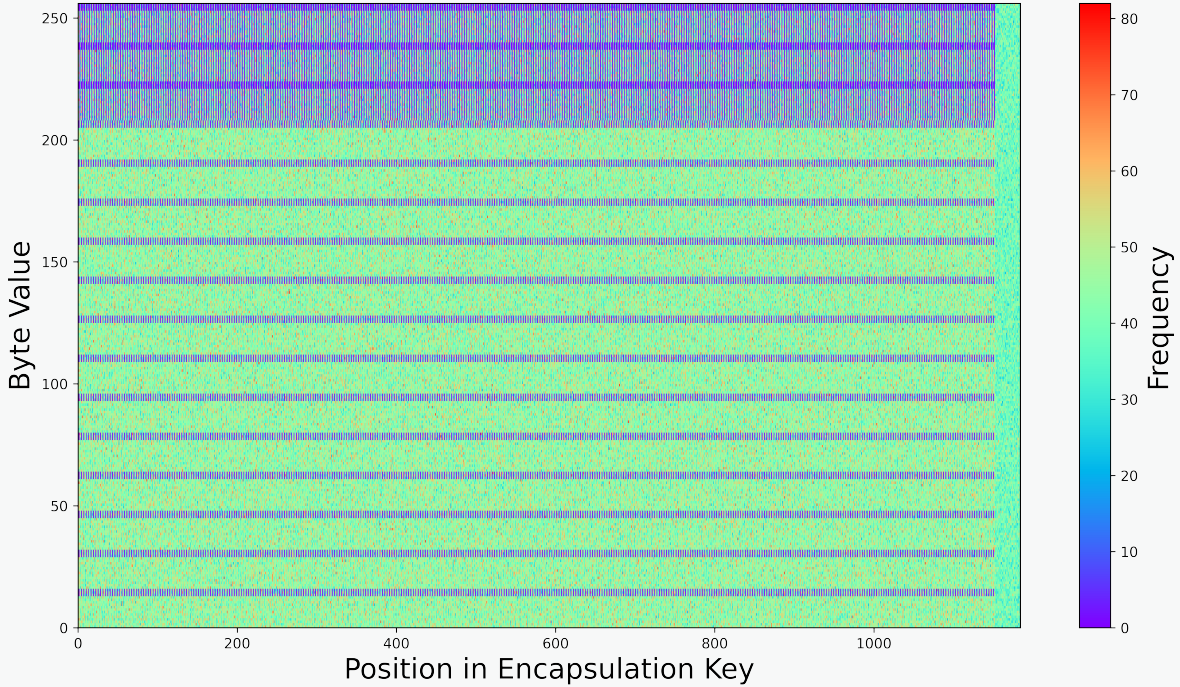

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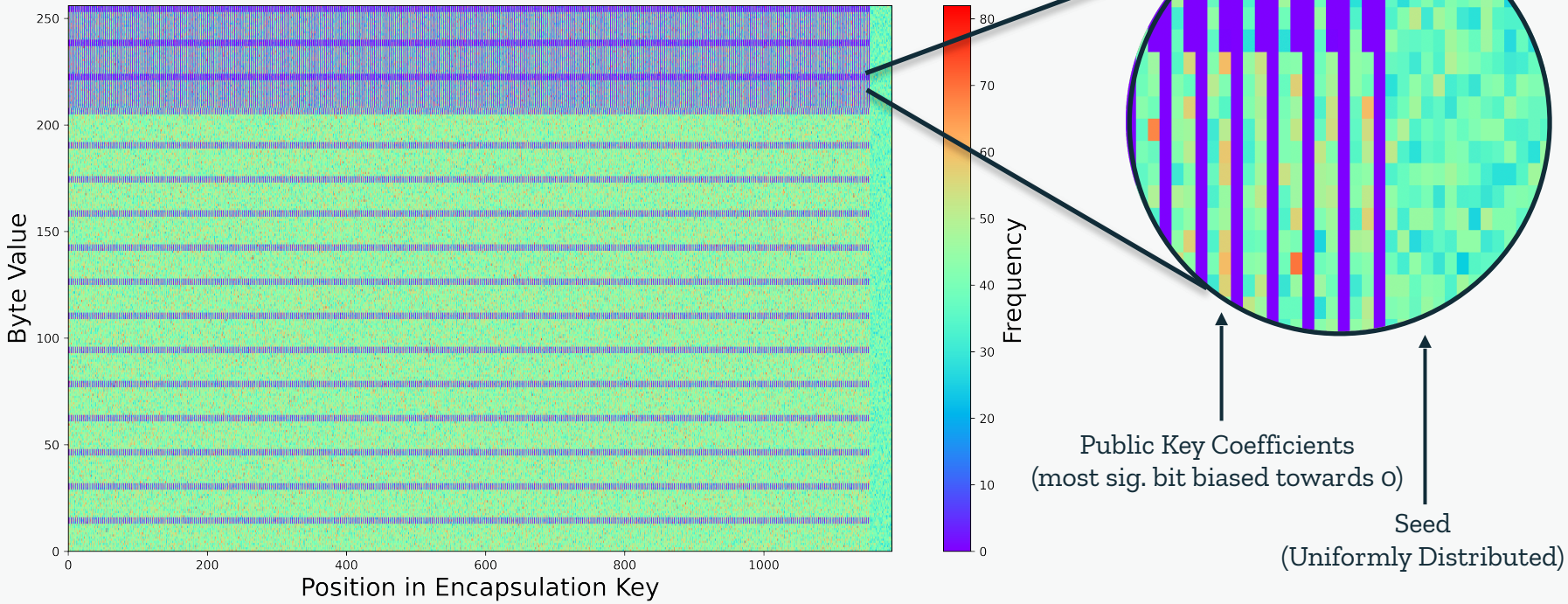

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Kemeleon: Rejection-Sampling Public Keys

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MLKEM-768 **likelihood of rejection is 17%** (Elligator likelihood of rejection is ~50%)

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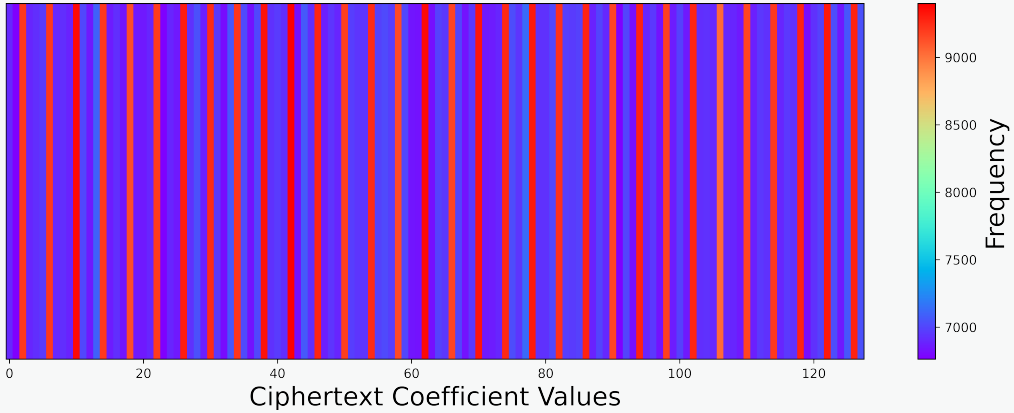

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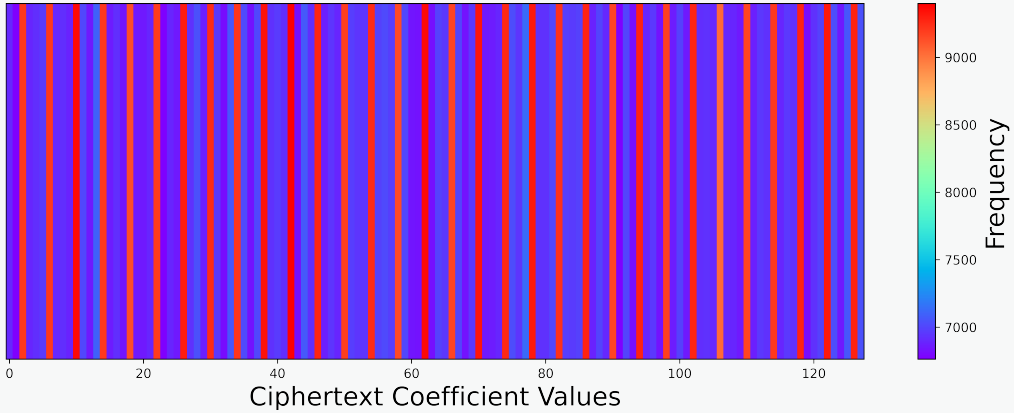

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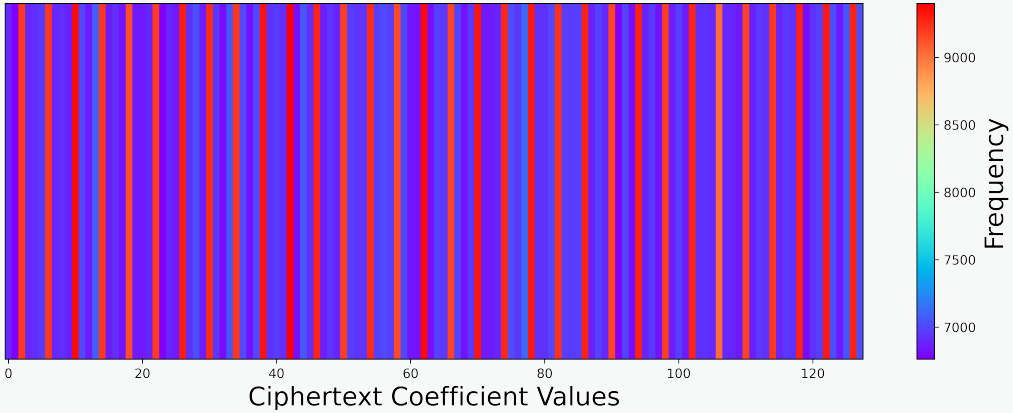

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Encoded ciphertexts are **6-15% larger** than regular (109/164/90 bytes for ML-KEM-512/768/1024)

Kemeleon without Rejection

Applying techniques from Tibouchi 2014 (Elligator²):

1. Take the accumulated integer, $\mathbf{A}$ (mod $\mathbf{q^{b-1}}$), from the original encoding with byte length < n

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Encoded public keys are **~ same size** as in standard ML-KEM.

Likelihood of rejection is **0%**

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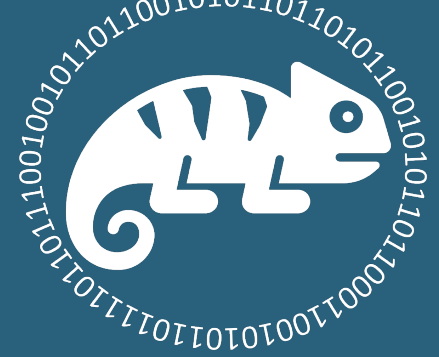

Using Kemeleon with ML-KEM: an OKEM

ML-KEM can naturally be combined with Kemeleon (by encoding public keys and ciphertexts) to obtain an *Obfuscated KEM* (OKEM)

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Note: while Elligator is statistically uniform, Kemeleon relies on MLWE assumption.

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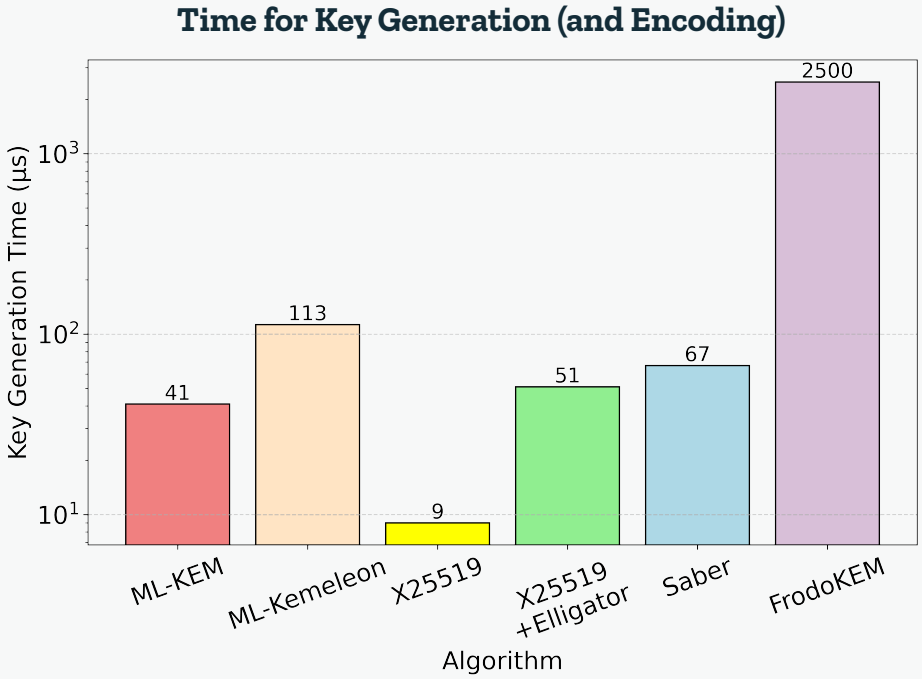

Constant-time Kemeleon implementation, non-rejection variant, NIST security level 3

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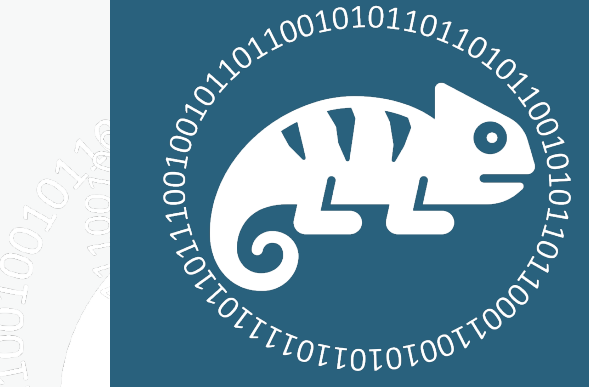

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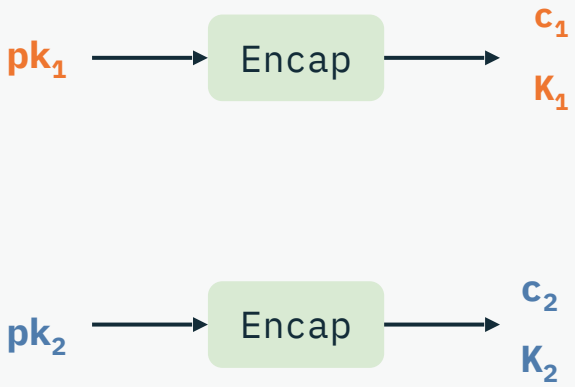

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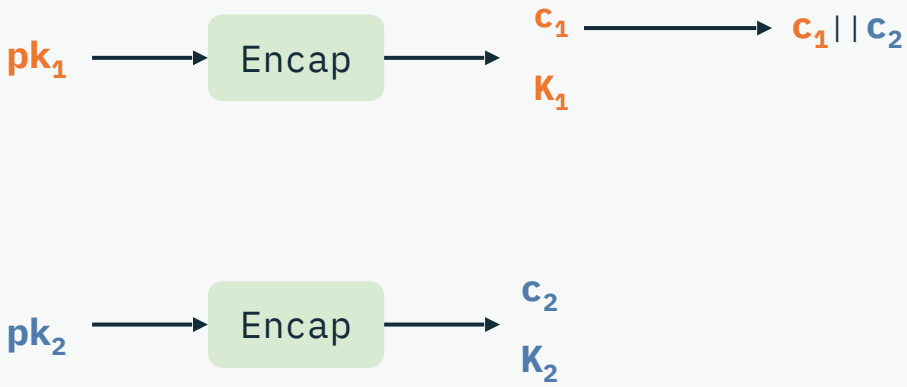

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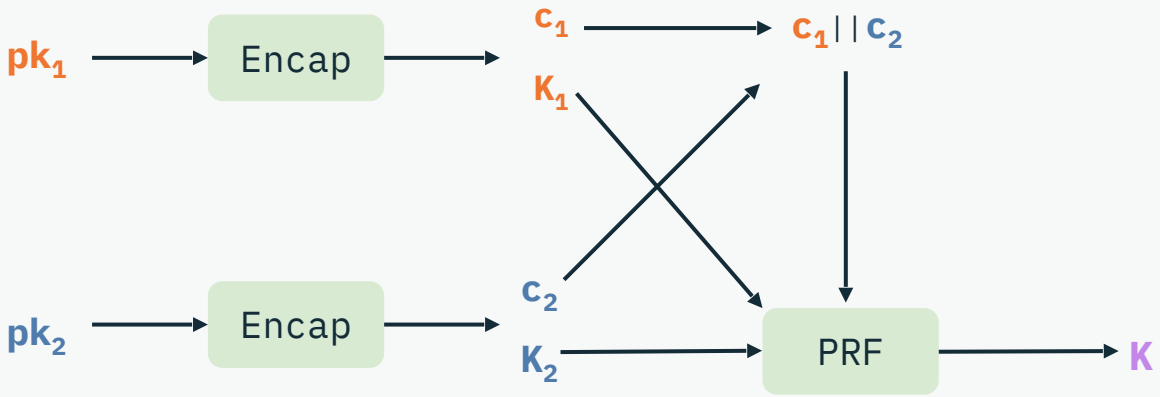

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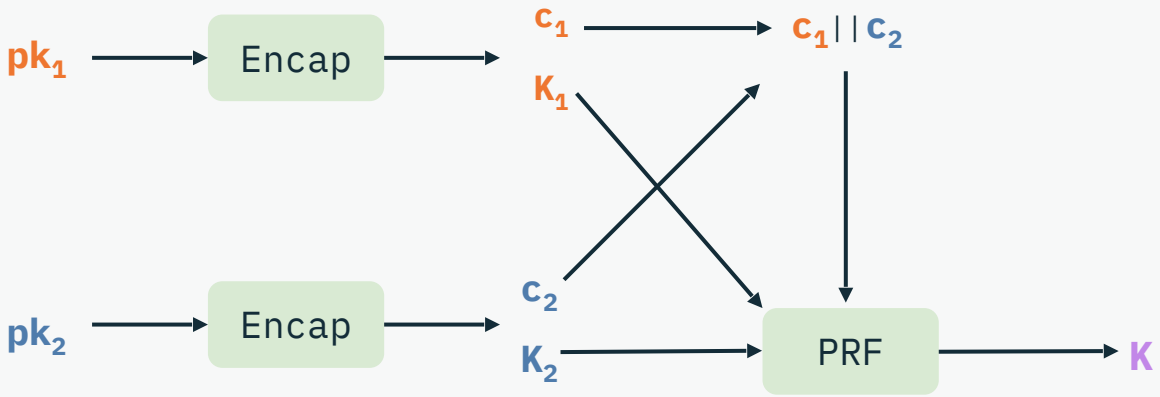

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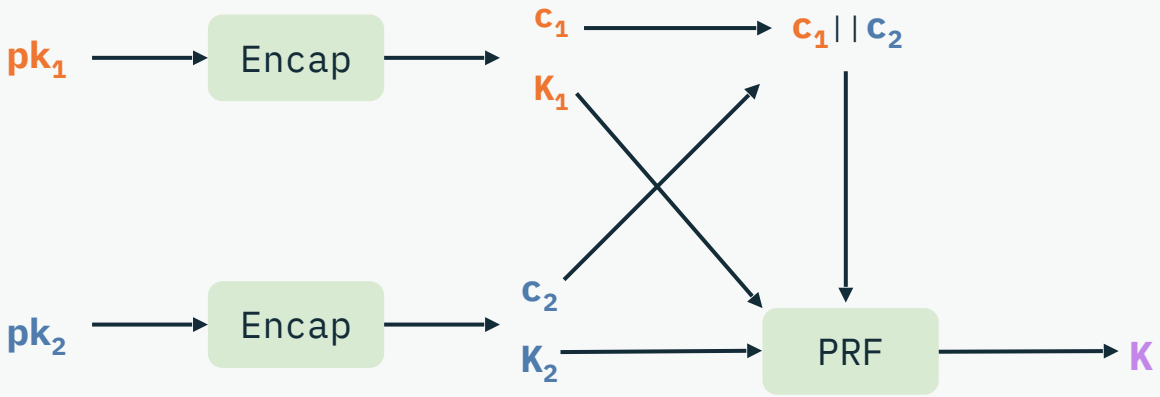

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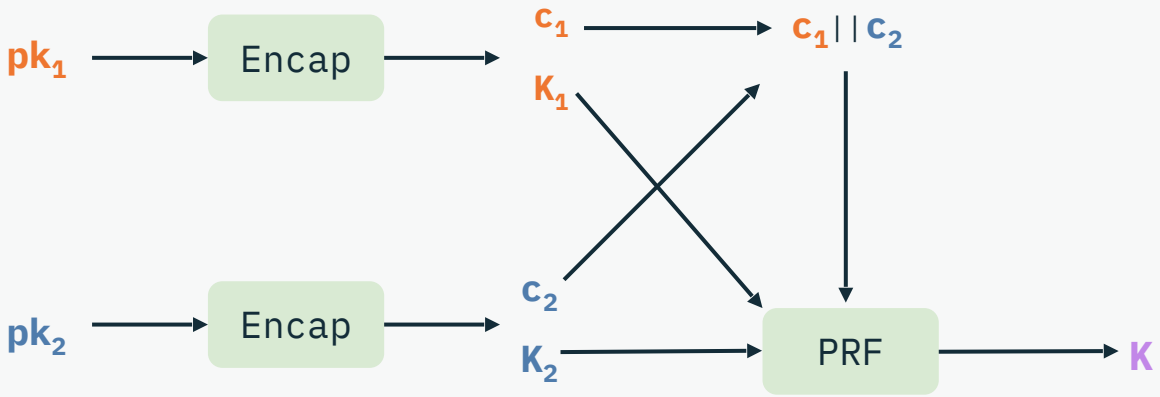

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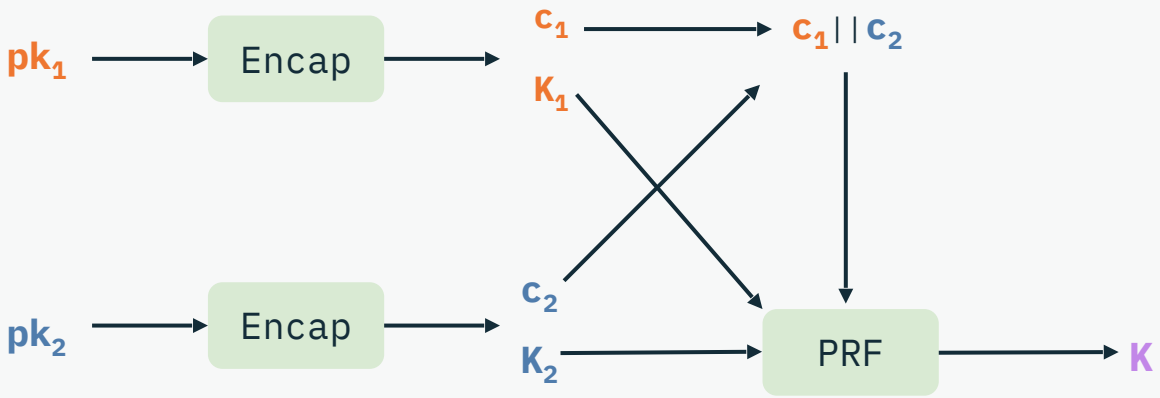

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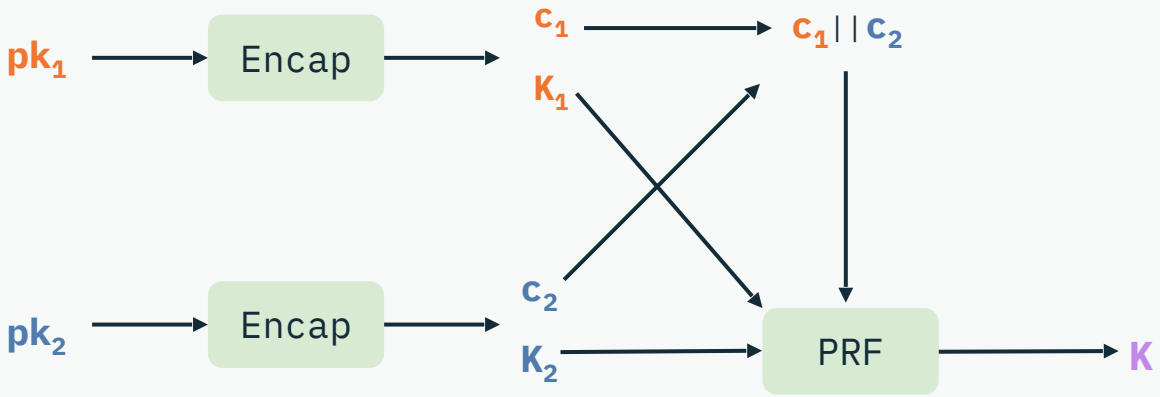

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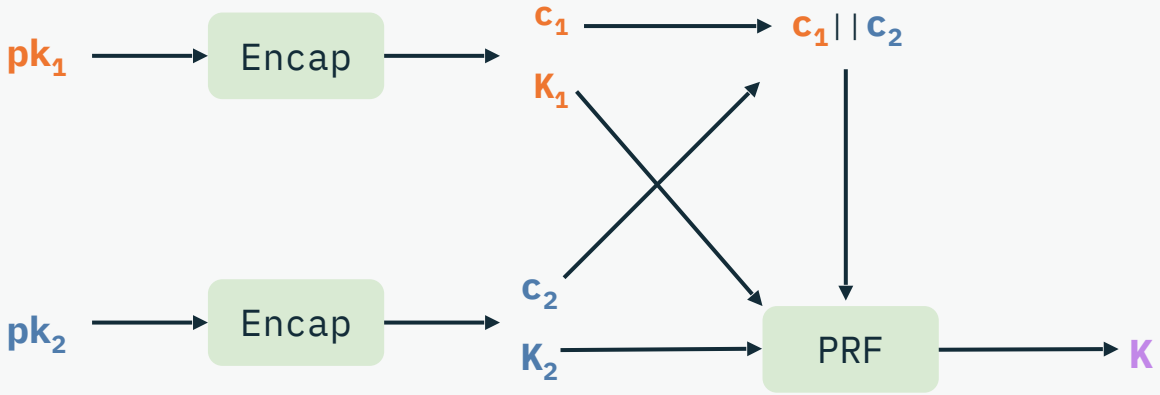

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Can we use c_1 to encrypt c_2?

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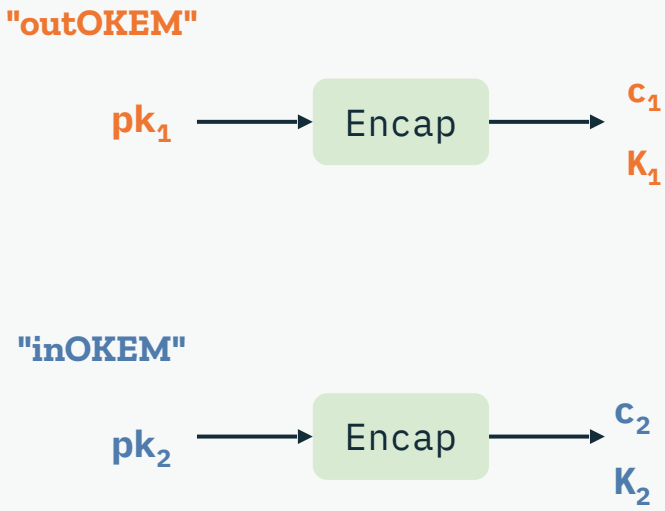

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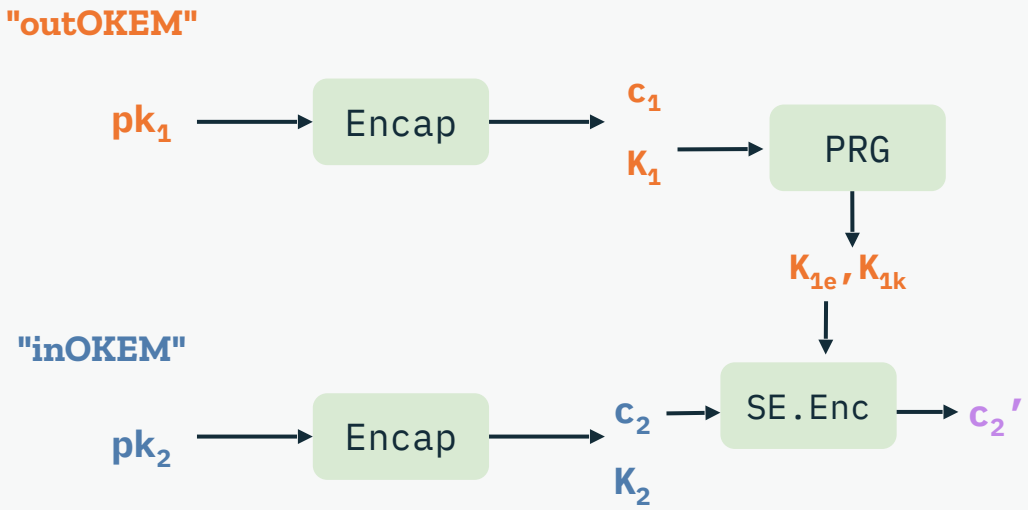

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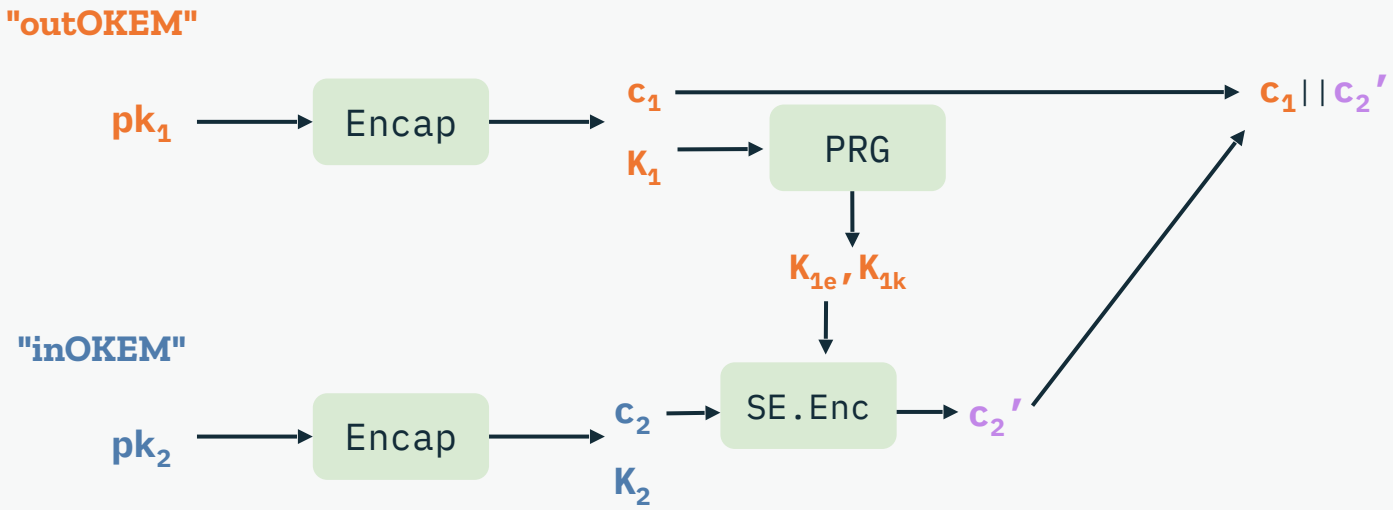

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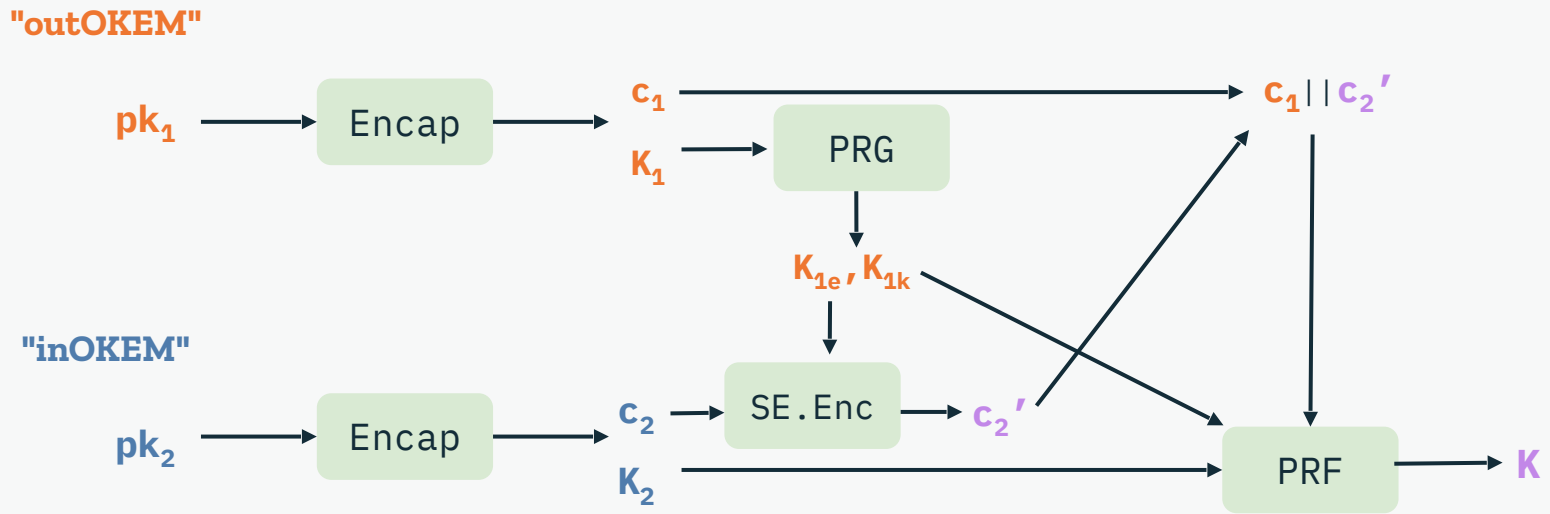

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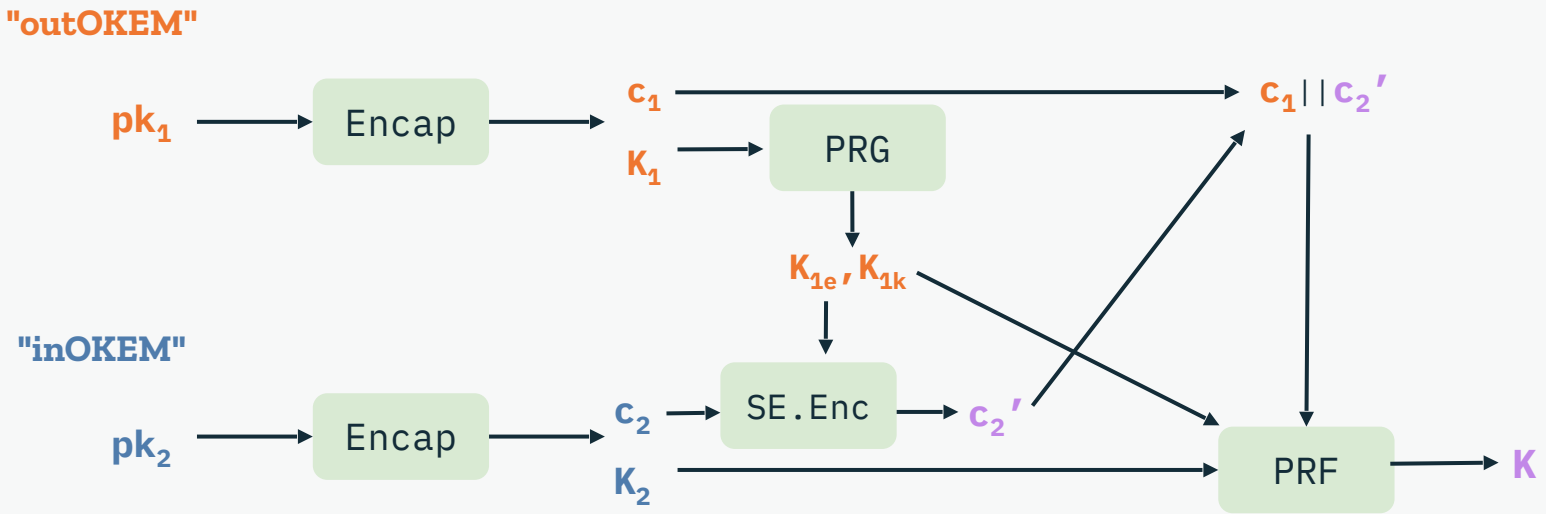

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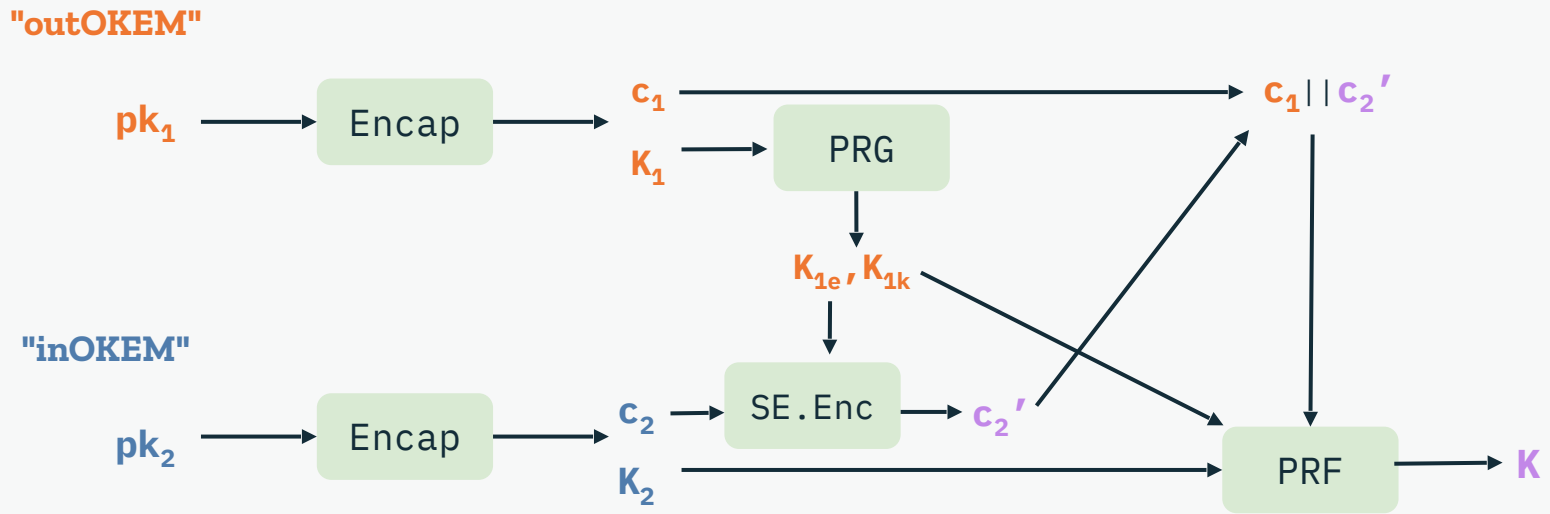

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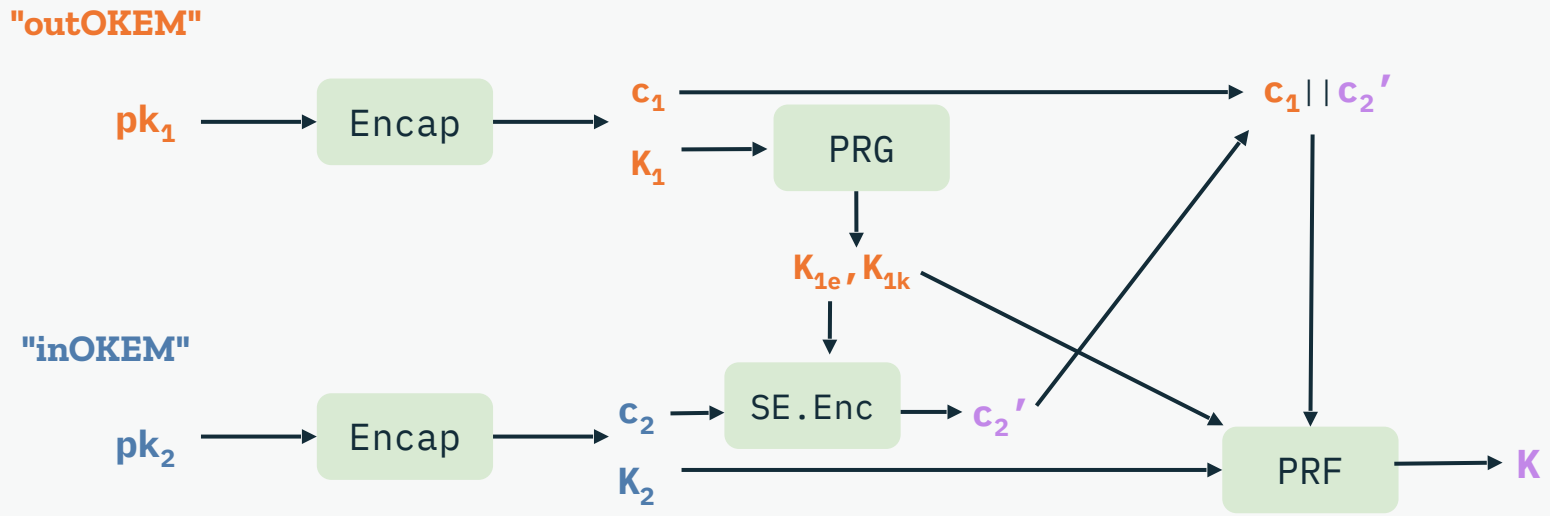

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Instantiating OEINC

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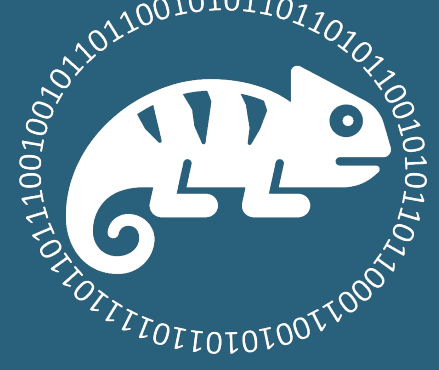
Concrete Instantiation

outOKEM = DHKEM[Ristretto]+Elligator2

inOKEM = ML-Kemeleon/Saber/Frodo

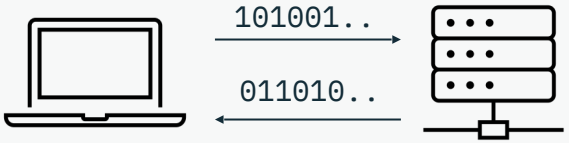
Overview

- Kemeleon Encoding
- ML-Kemeleon: Obfuscated PQ KEM
- OEINC: Obfuscated KEM Combiner
- **Hybrid Applications:**
  - **Obfuscated Key Exchange**
  - Password Authenticated Key Exchange (with adaptive security)



Hybrid Obfuscated Key Exchange

- All **handshake traffic** should appear **indistinguishable from random** (or simulatable).



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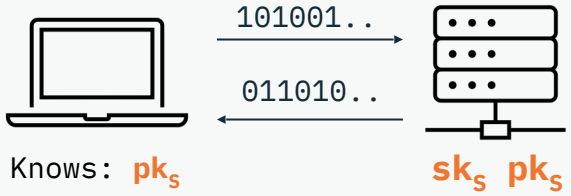

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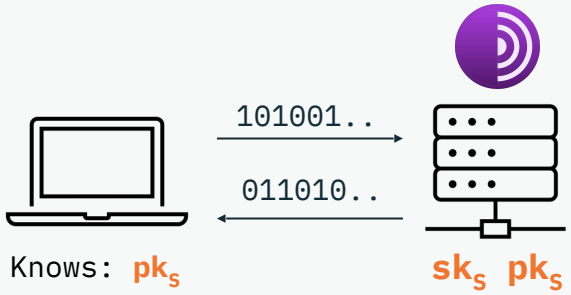

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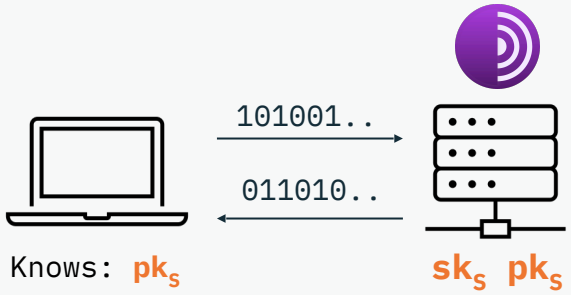
Existing KEM-based protocol requires **hybrid public key uniformity**



Hybrid Obfuscated Key Exchange

Drivel: A Hybrid Obfuscated Key Exchange Protocol

(O)KEM-based AKE

Client **Server** sk_S pk_S

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(O)KEM-based AKE

Ephemeral and static hybrid (O)KEM encapsulations

Client

Server sk_s pk_s

$(sk_e, pk_e) := KEM.Keygen()$

pk_e →

$(c_2, K_2) := KEM.Encap(pk_e)$

← c_2

$K_2 := KEM.Decap(sk_e, c_2)$

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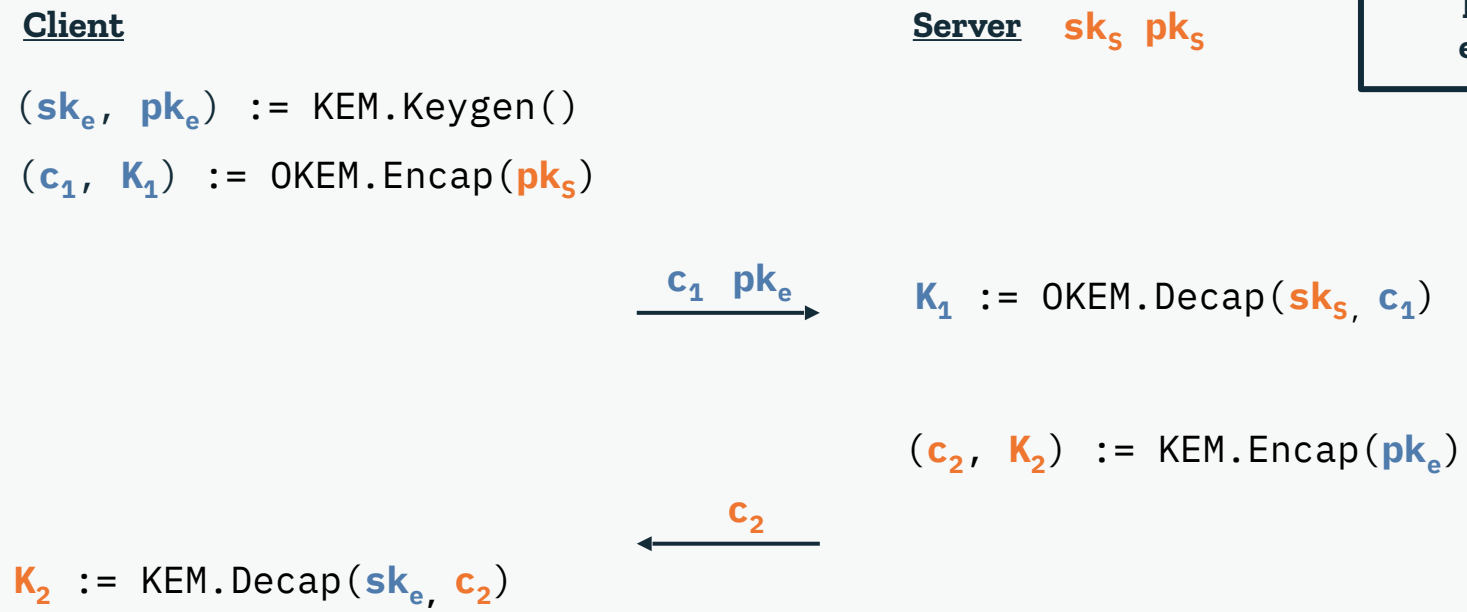

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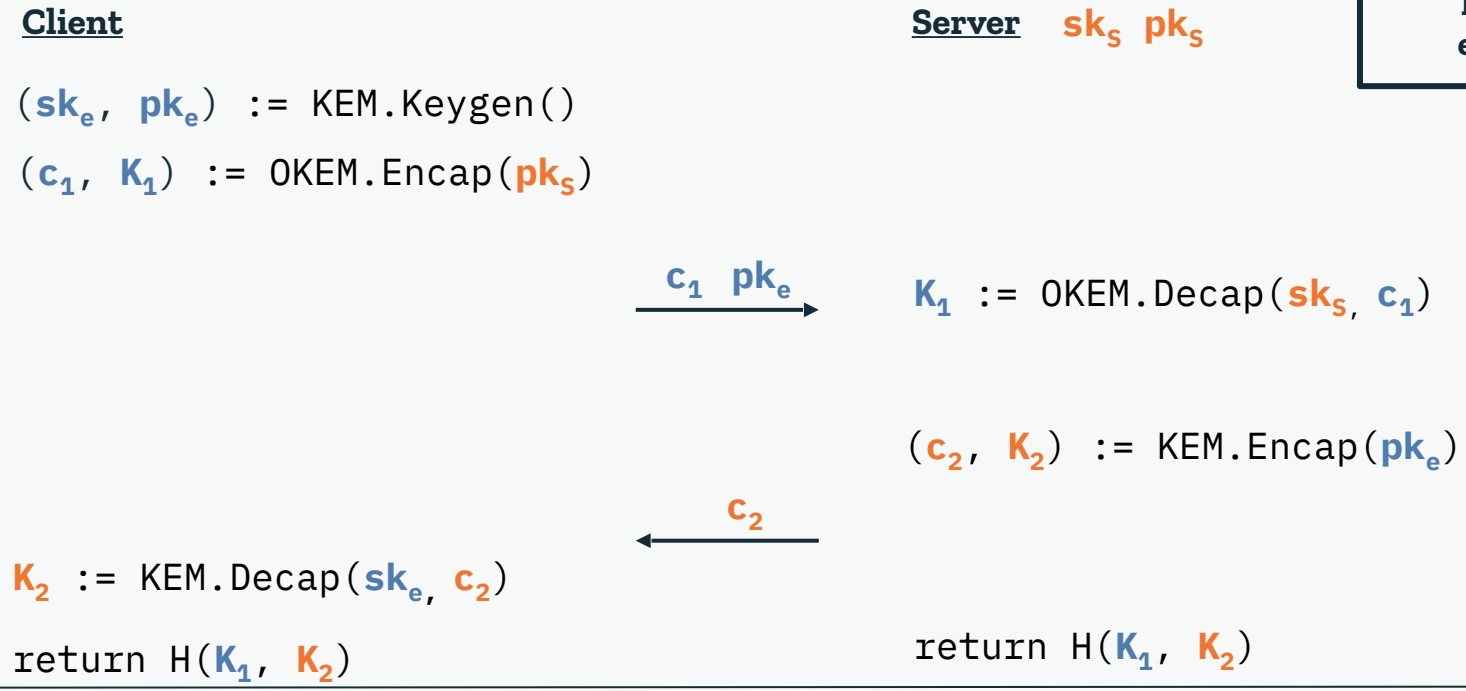

Hybrid Obfuscated Key Exchange

Drivel: A Hybrid Obfuscated Key Exchange Protocol

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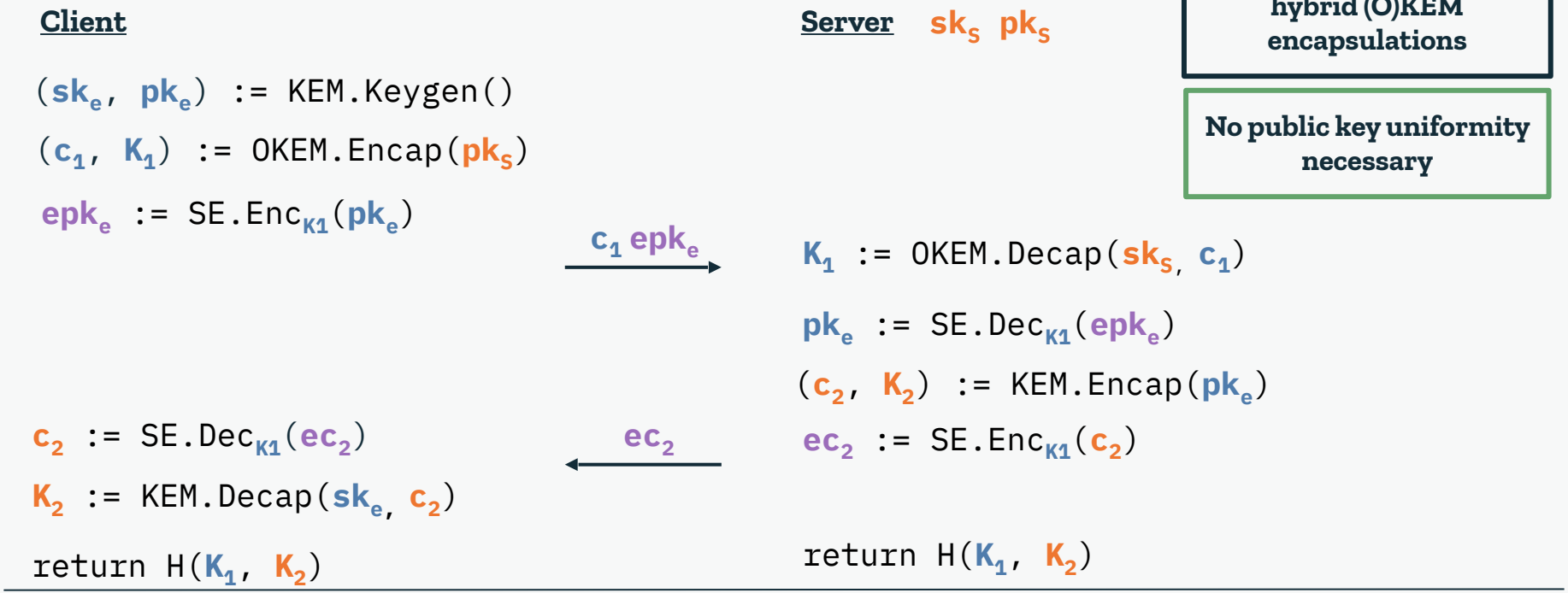
No public key uniformity necessary



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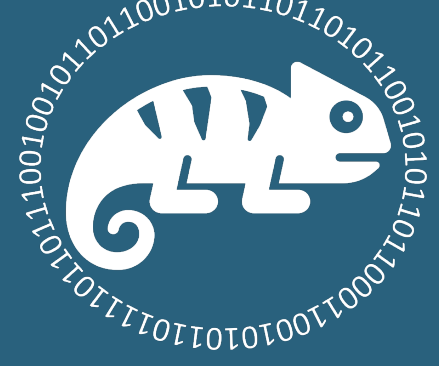

Applications of OEINC: Hybrid PAKE

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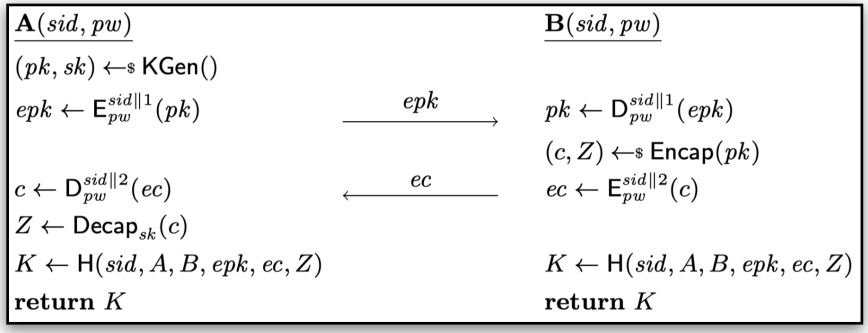

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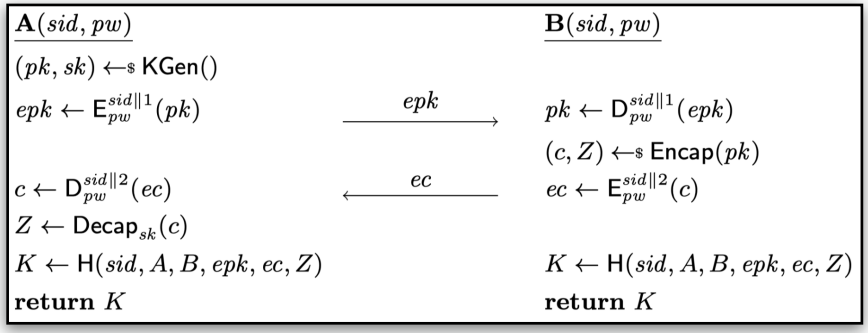

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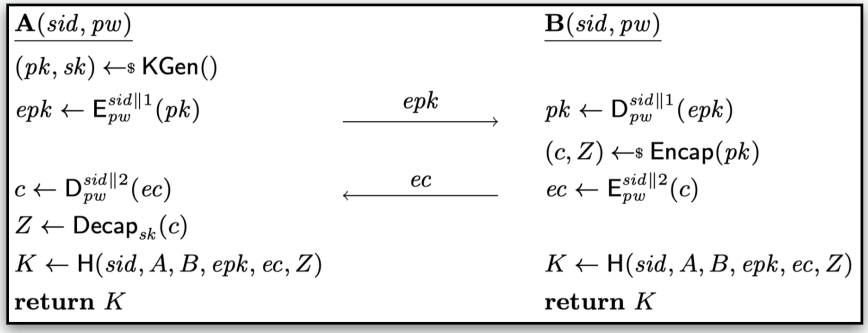

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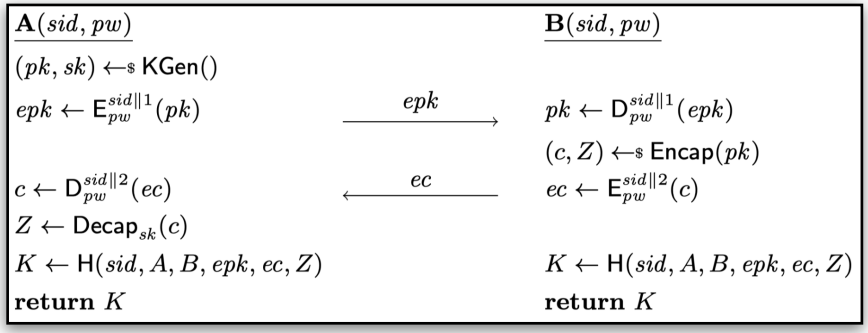

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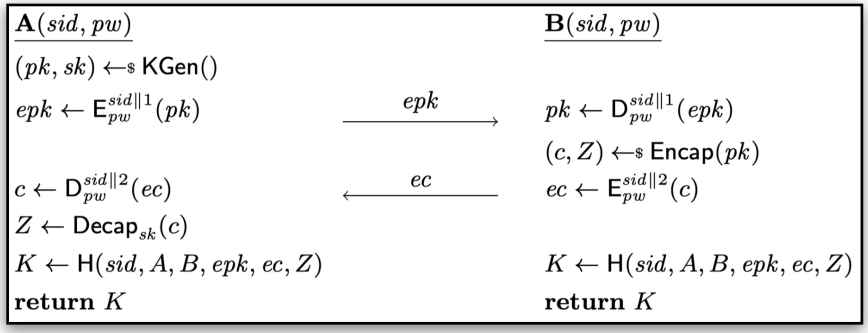

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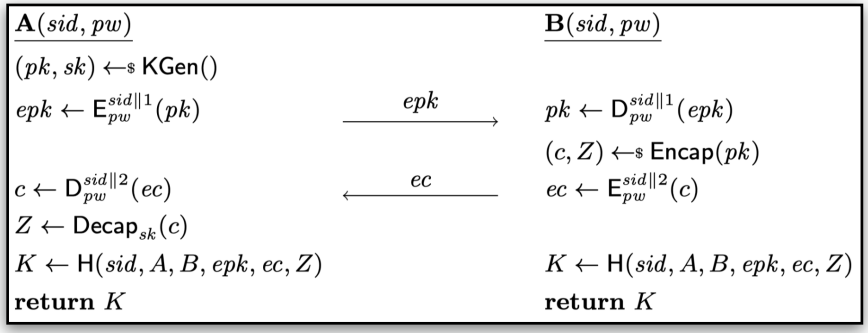

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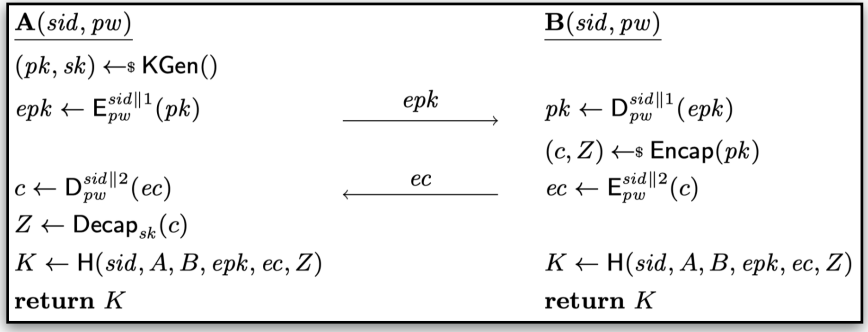

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7.5x comms overhead compared to 3-round PAKEs

Thanks! Questions?

Kemeleon: Elligator-like Obfuscation for Post-Quantum Cryptography

We made:

- an encoding for ML-KEM
- an OKEM from ML-KEM
- an OKEM combiner

We got:

- Hybrid obfuscated key exchange
- Hybrid PAKE

References:

- Günther, Stebila, Veitch. Obfuscated Key Exchange. CCS 2024. ia.cr/2024/1086
- Günther, Stebila, Veitch. Kemeleon Encodings. Internet-Draft. https://datatracker.ietf.org/doc/draft-veitch-kemeleon/ **<— send us your feedback!**
- Günther, Rosenberg, Stebila, Veitch. Hybrid Obfuscated KEMs and Key Exchange. ia.cr/2025/408