Key-committing AEAD

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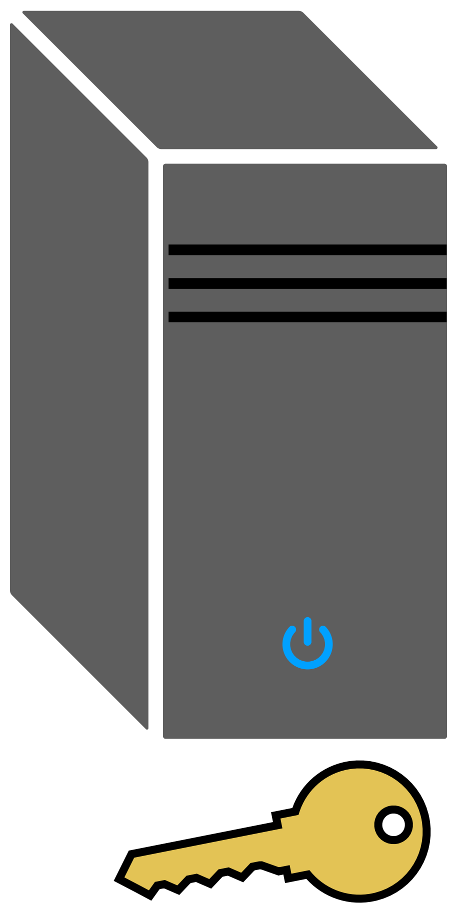
CFRG, IETF 110

For simplicity, we ignore nonces and associated data in this presentation

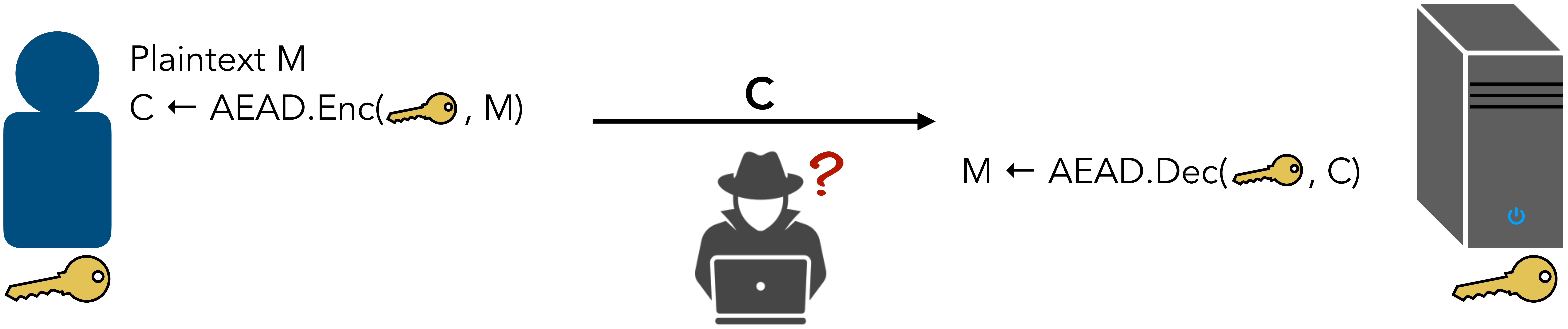
Authenticated Encryption

Plaintext M

C ← AEAD.Enc(, M)



Authenticated Encryption



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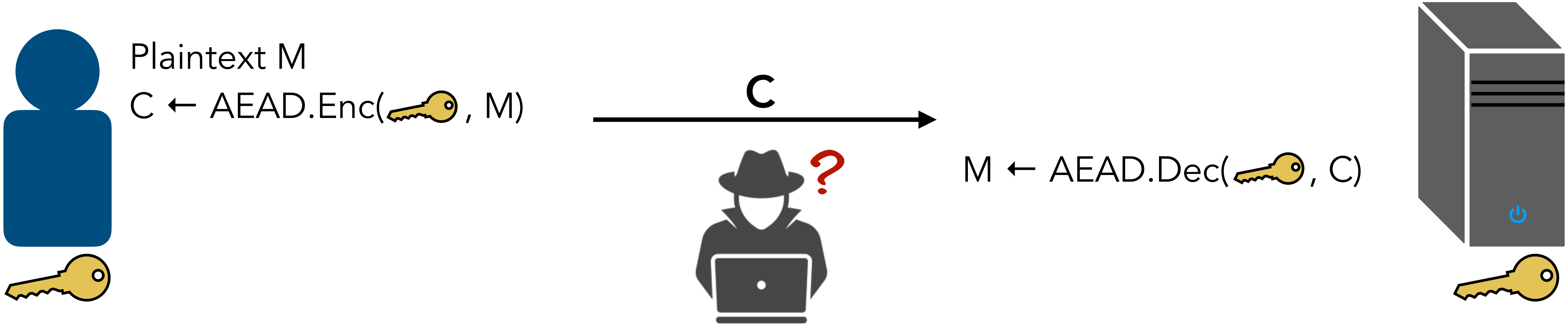

Popular

- AES-GCM
- XSalsa20/Poly1305
- ChaCha20/Poly1305
- AES-GCM-SIV
- OCB

Easy to use

- Efficient
- Standardized
- Widely supported

Secure

- Proven CCA-secure
- Confidentiality
- Integrity

Authenticated Encryption

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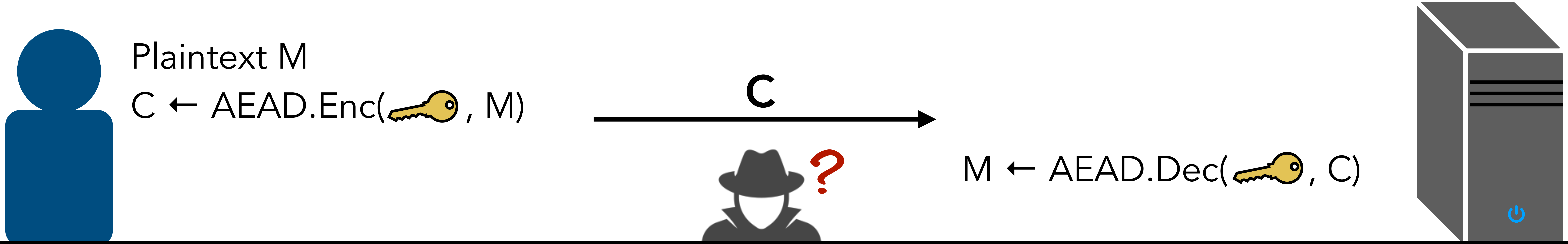

But don’t target robustness, also called **committing AEAD**, as a security goal

[ABN TCC’10], [FLPQ PKC’13] for PKE, [FOR FSE’17] for AEAD

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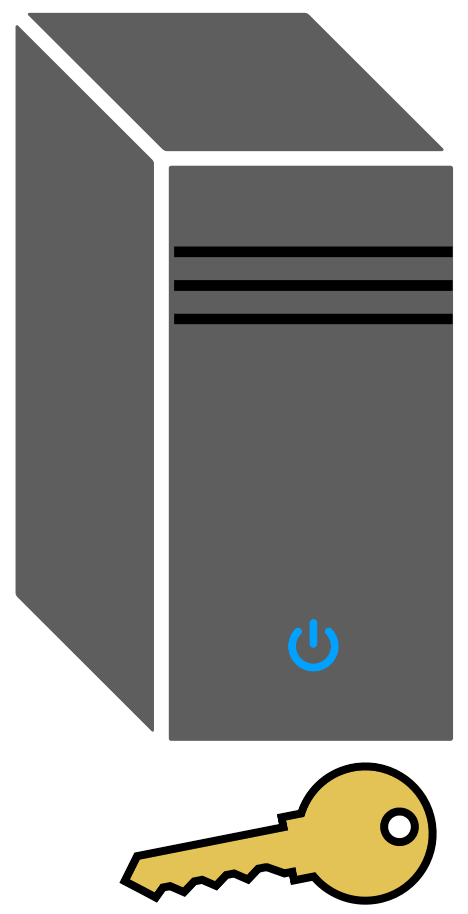
(Non-) Committing AEAD

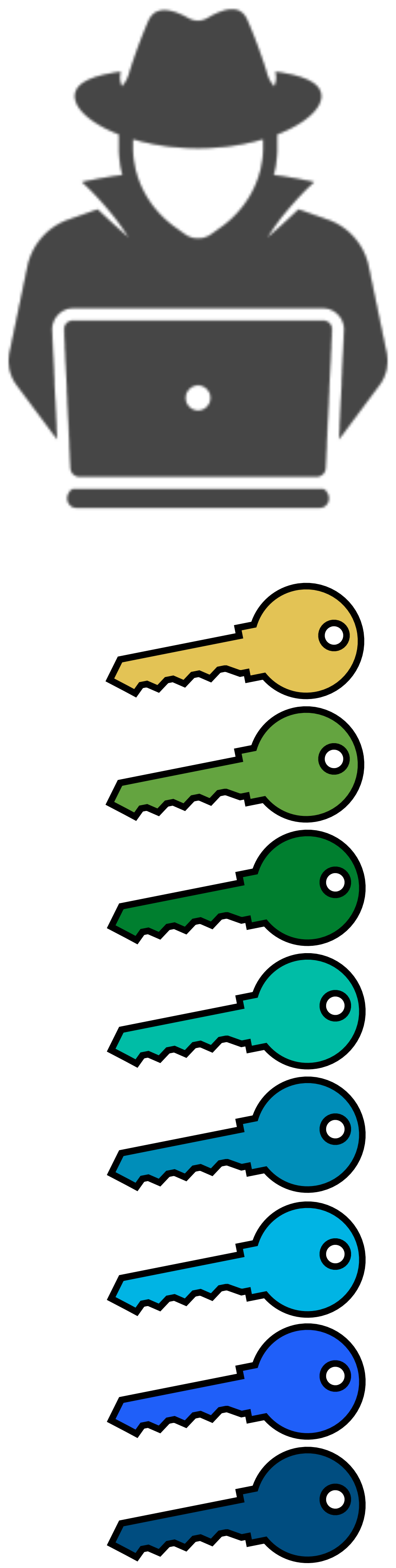
Ciphertext C′

$M_1 \leftarrow \text{AEAD.Dec}(\ ,\ C')$

$M_2 \leftarrow \text{AEAD.Dec}(\ ,\ C')$



Partitioning Oracle Attacks [LGR USENIX'21]



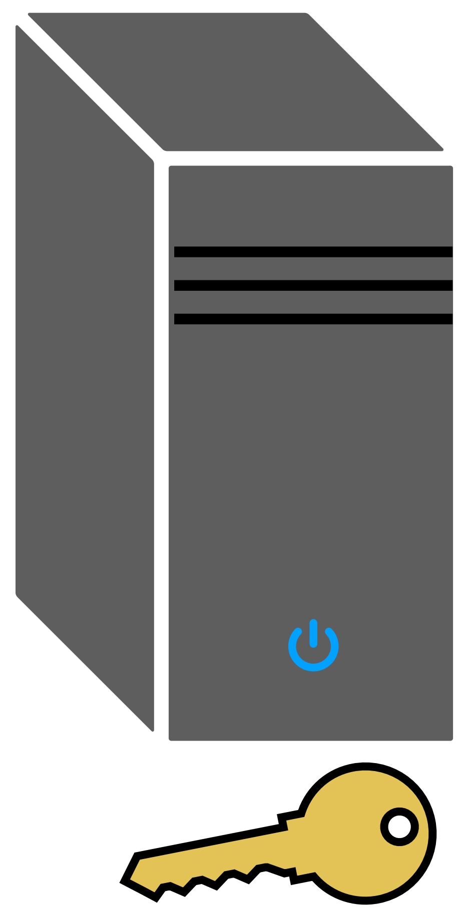
Ciphertext C′

$M_1 \leftarrow$ AEAD.Dec(, C′)

$M_2 \leftarrow$ AEAD.Dec(, C′)

$M_3 \leftarrow$ AEAD.Dec(, C′)

$M_4 \leftarrow$ AEAD.Dec(, C′)



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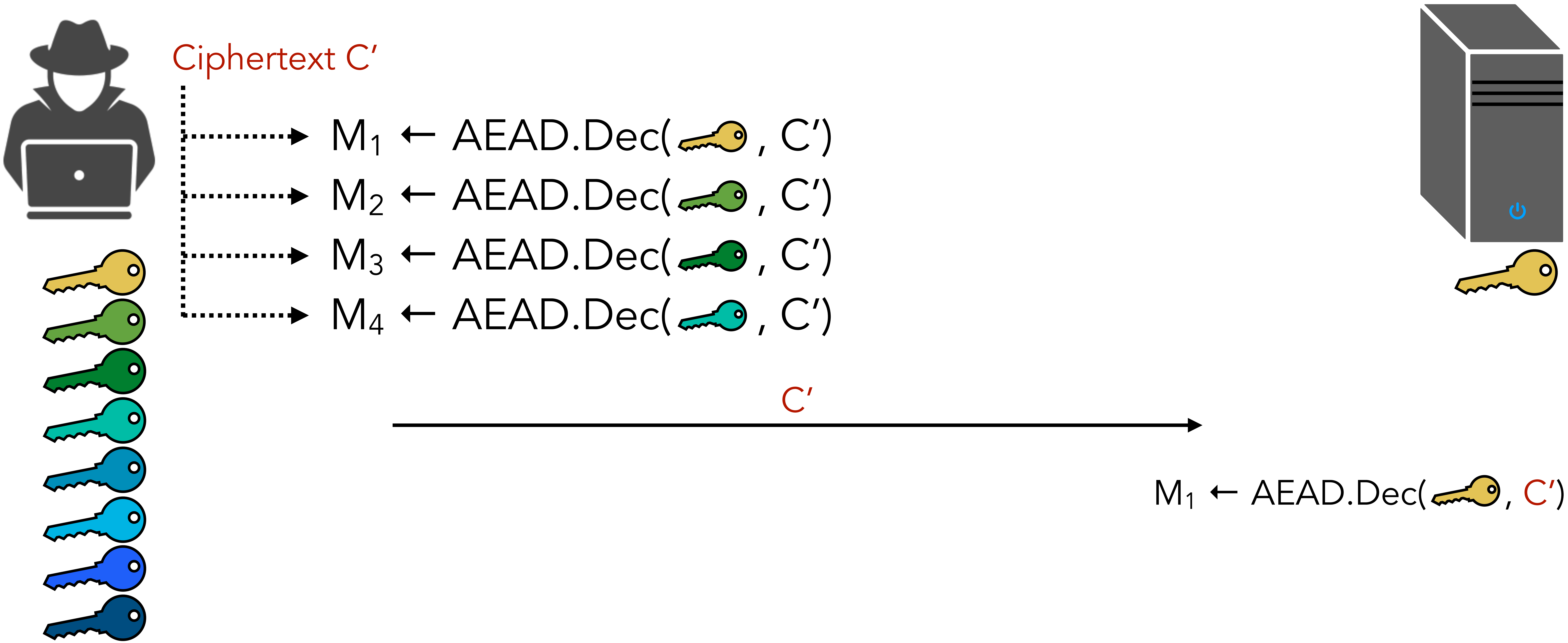

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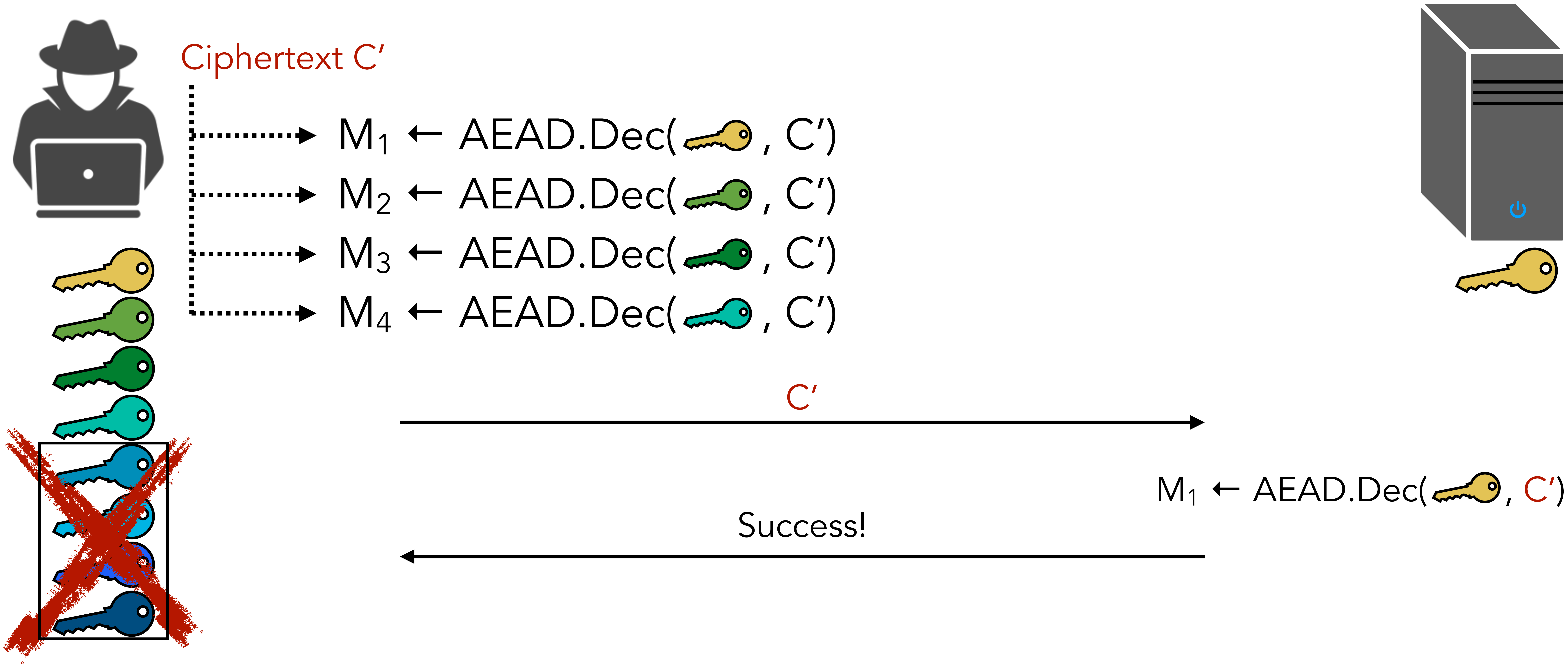
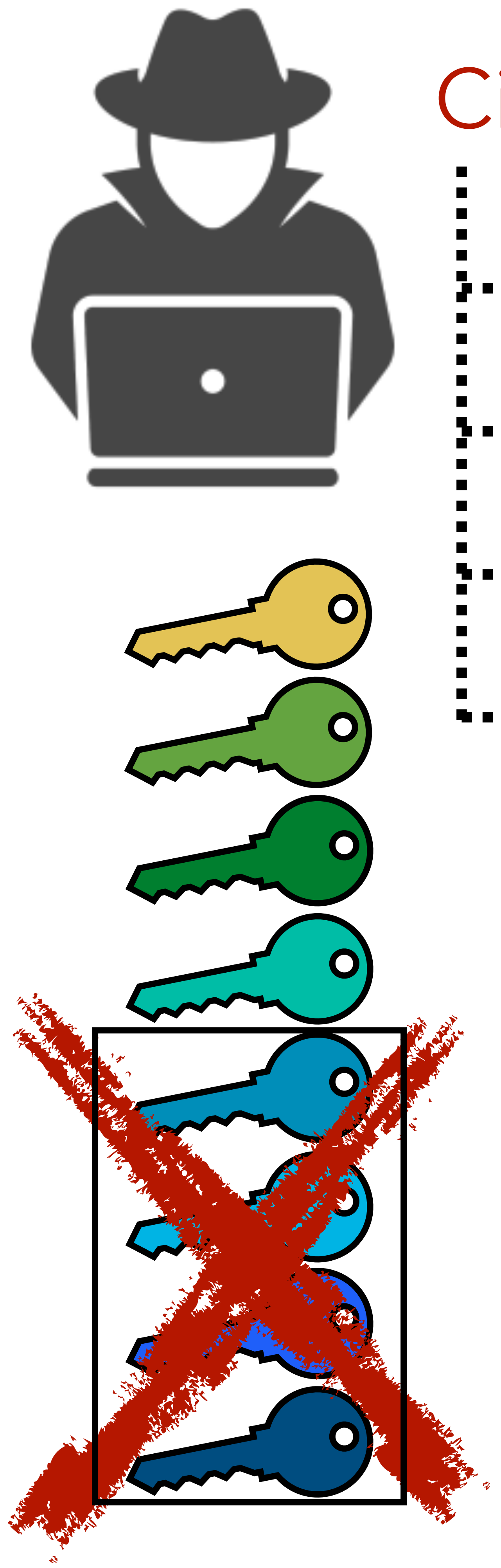


Partitioning Oracle Attacks [LGR USENIX'21]

The attacker learns 1-bit of information about the key!



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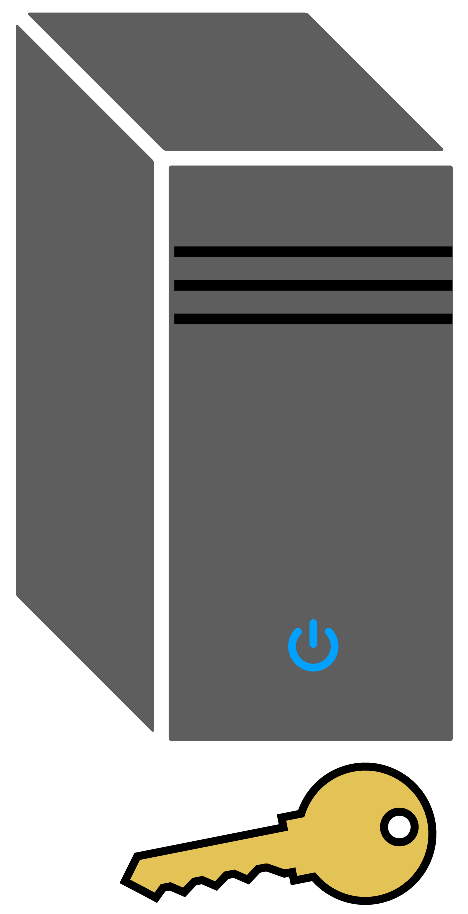

C′

$M_1 \leftarrow$ AEAD.Dec(, C′)

Success!

Vulnerabilities from non-committing AEAD (so far)

- Facebook Messenger
- Message franking

Content moderation

[GLR CRYPTO'17]
[DGRW CRYPTO'18]

- Key rotation in key management services
- Envelope encryption in the AWS encryption SDK
- Subscribe with Google

Services by Google & Amazon

[ADGKLS '20]

Partitioning oracle attacks

Schemes looked at in depth

- Shadowsocks proxy servers for UDP
- Early implementations of the OPAQUE asymmetric PAKE protocol

Possible partitioning oracles

- Hybrid encryption: Hybrid Public-Key Encryption (HPKE)
- Age file encryption tool
- Kerberos drafts (not adopted)
- JavaScript Object Signing and Encryption (JOSE)
- Anonymity systems: use partitioning oracles to learn which public key a recipient is using from a set of public keys

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Scheme	Description	Adopted by…	Extra overhead over base scheme	Potential issues?
Zeros Block Check	Modifies AEAD scheme to check that a block of recovered plaintext is all-zeros string	Libsodium	Adds **64 bytes** to each ciphertext	• Side-channel if implemented incorrectly • Need to implement and analyze separately for each AEAD scheme
Hash Key Check	Modifies AEAD scheme to check SHA256 hash of the key during decryption	AWS Encryption SDK	Adds at least **32 bytes** to each ciphertext	Side-channel if implemented incorrectly
Single-key Encrypt-then-HMAC	Plain Encrypt-then-HMAC using single key	-	None!	Less efficient

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- None currently standardized!
- As we begin the process of making an internet-draft, we would love to hear your thoughts about needs and requirements

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References

[ABN TCC’10] Michel Abdalla, Mihir Bellare, Gregory Neven. Robust Encryption. TCC, 2010.

[FLPQ PKC’13] Pooya Farshim, Benoît Libert, Kenneth Paterson, Elizabeth Quaglia. Robust encryption, revisited. PKC, 2013.

[FOR FSE’17] Pooya Farshim, Claudio Orlandi, Răzvan Roşie. Security of symmetric primitives under incorrect usage of keys. FSE, 2017.

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[ADGKLS ’20] Ange Albertini, Thai Duong, Shay Gueron, Stefan Kölbl, Atul Luykx, Sophie Schmieg. How to abuse and fix authenticated encryption without key commitment. ePrint 2020/1456.