AE and AEAD

Right now we know

- **Encryption** which takes care of the confidentiality problem

> an attacker cannot get any info about the plaintext from a ciphertext

- **MAC** which takes care of **Integrity**

> An authorized party (receiver) can check if the data is genuine or tempered with

But we have yet to define a method that combines them. We are going to do it now

Authenticated Encryption

> Authenticated encryption (AE) provides confidentiality and data authenticity simultaneously.

Security

> A Secure AE system is secure against chosen ciphertext attacks

Let

- (E, D) = cipher
- (S, V) = MAC

Types

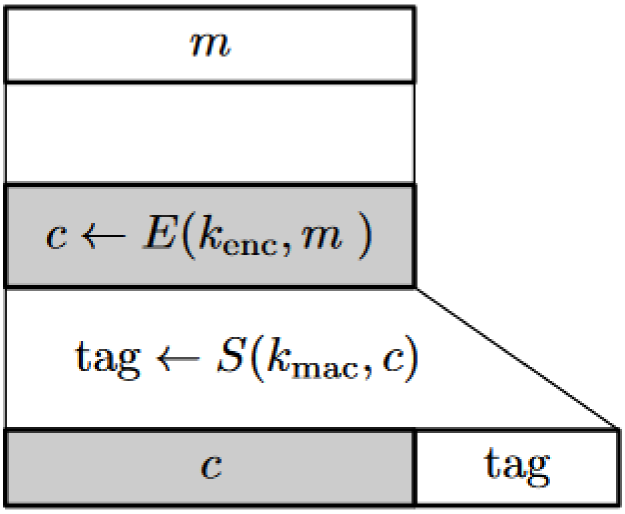
Encrypt-then-MAC

Encryption

- $c = E(k_e, m)$
- $t = S(k_m, c)$

Decryption

- $V(k_m, c, t)$
    - = reject $\Rightarrow reject$
    - = accept $\Rightarrow$ return $D(k_e, c)$


m
$c \leftarrow E(k_{\text{enc}}, m)$
$\text{tag} \leftarrow S(k_{\text{mac}}, c)$
c
tag

encrypt-then-mac

Mistakes

- $k_e = k_m$ -> they must be chosen independently
- apply the MAC to only a part of the ciphertext
  - Ex: Not signing the IV in a CBC mode => An attacker can queue a custom IV' and the challenger must decrypt c

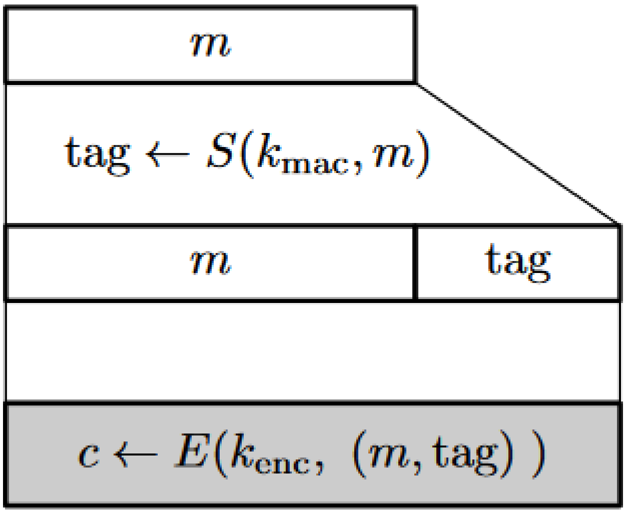
MAC-then-Encrypt

Encryption

- $t = S(k_{mac}, m)$
- $c = E(k_{enc}, (m, t))$

Decryption

- $(m, t) = D(k_e, c)$
- $V(k_m, m, t)$
  - = reject => reject
  - = accept => return m


m
$\text{tag} \leftarrow S(k_{\text{mac}}, m)$
m
tag
$c \leftarrow E(k_{\text{enc}}, \ (m, \text{tag}) \ )$

-

Broken

- Vulnerable to CCA
  - Padding oracle attacks https://www.youtube.com/watch?v=O5SeQxErXA4

Encrypt-and-MAC

- $t = S(k_{mac}, m)$
- $c = E(k_enc, m)$

Broken too

The MAC is not designed for confidentiality => It can reveal information about the message

Authenticated Encryption with Additional Data

Extension of AE

- We give AE an additional input -> **Associated data** d
- Integrity protected, Secrecy not
- $c = E(k, m, d, n)$ where n is a nonce
- m or reject = $D(k, c, d, n)$

Security

> AEAD is secure if (E, D) is CPA secure and has ciphertext integrity

Encrypt then MAC

Encryption

- $c = E(k_e, m, n)$
- $t = S(k_m, (c, d), n)$

Decryption

- V(k_m, (c, d), t, n)
  - = reject $\Rightarrow reject$
  - = accept $\Rightarrow D(k_e, c, d, n)$

Resources

- https://en.wikipedia.org/wiki/Authenticated_encryption
- https://crypto.stackexchange.com/questions/12178/why-should-i-use-authenticated-encryption-instead-of-just-encryption
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