Caveat Implementor!
Key Recovery Attacks on MEGA

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24 April 2023

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- MEGA did not implement suggested countermeasures, instead relying on validation of plaintext payloads
- These checks were sufficient to prevent the specific attacks, but (as we will show) not sufficient in general

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- the key overwriting attacks on OpenPGP [KR02, BPH22]

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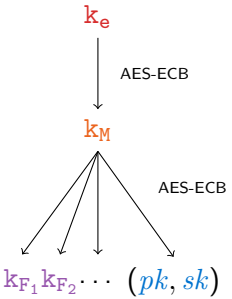

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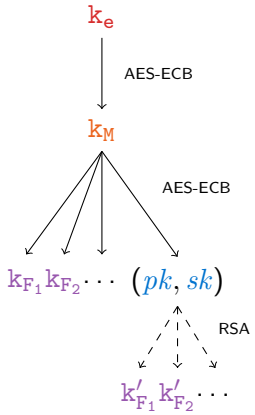
- *Shared-file encryption keys* $\mathtt{k'_F}$ are encrypted under pk using RSA



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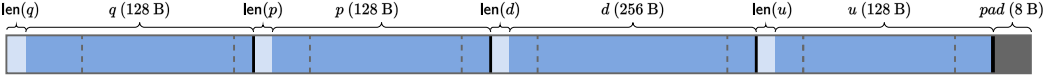

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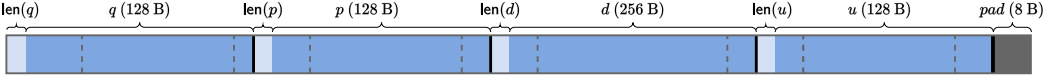

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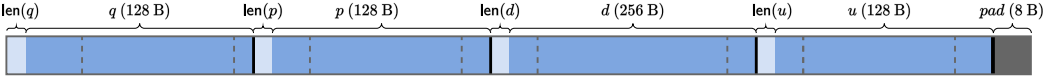

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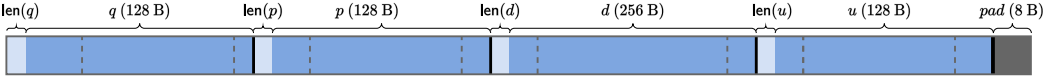

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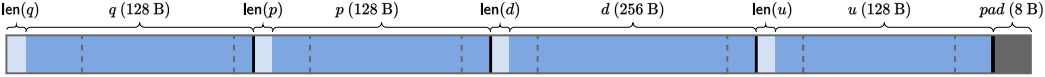

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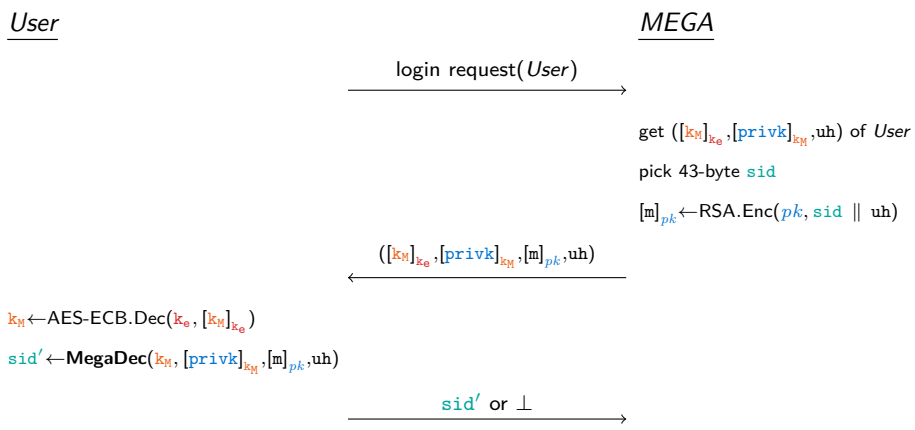
- Split into 16-byte blocks for AES-ECB

MEGA login procedure



Client decryption and parsing

MegaDec($\mathtt{k_M}$, $[\mathtt{privk}]_{\mathtt{k_M}}$, $[\mathtt{m}]_{pk}$, $\mathtt{uh}$):

1. $sk \leftarrow \mathsf{DecryptPrivk}(\mathtt{k_M}, [\mathtt{privk}]_{\mathtt{k_M}})$ // AES-ECB
2. $\mathtt{sid}' \leftarrow \mathsf{DecryptSid}(sk, [\mathtt{m}]_{pk})$ // RSA-CRT
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Both steps rely on validity checking of the decrypted values and return distinguishable errors to the server!

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Explicit errors due to validity checking:

- In DecryptSid($sk, \cdot$), a length check on the plaintext together with a legacy padding check reveal if the second byte of `m` is 0
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Implicit errors due to bugs in the low-level library:

- In DecryptPrivk($\mathtt{k_M}, \cdot$), failure in recomputing $u' \leftarrow q^{-1} \bmod p$ reveals if $\gcd(p, q) \neq 1$
  $\implies$ attack based on modular inverses (#1)

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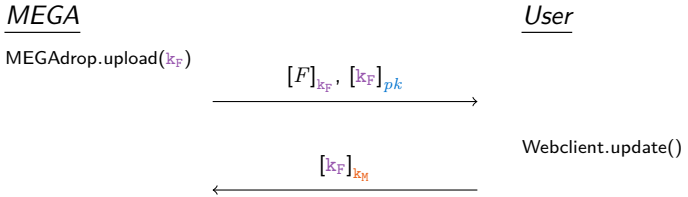

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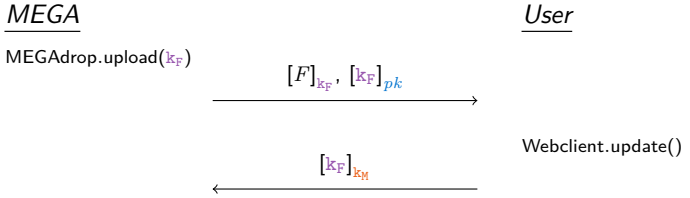

A malicious provider can construct an ECB encryption oracle *without user interaction* and *without leaving traces*

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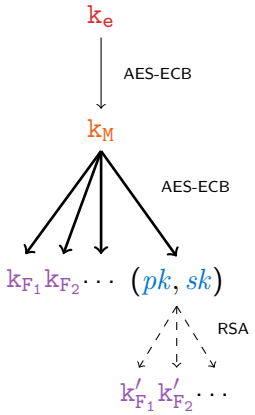

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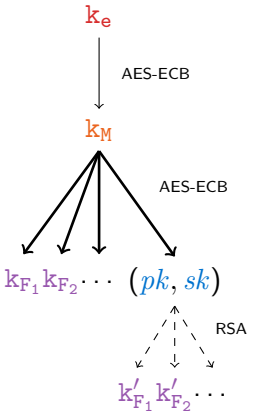
Cost measured mainly in the number of login attempts



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Let $[B]_{\mathtt{k_M}}$ be the target ciphertext block, $\mathrm{OECB}_{\mathtt{k_M}}$ be the ECB encryption oracle, and $\perp_{\mathsf{inv}}$ be the error output by **MegaDec** if $\gcd(p, q) \neq 1$

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Average cost: 627 login attempts and 66-91 OECB_{k_M} queries

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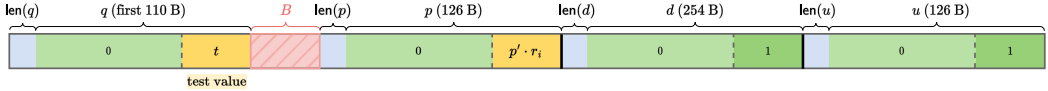

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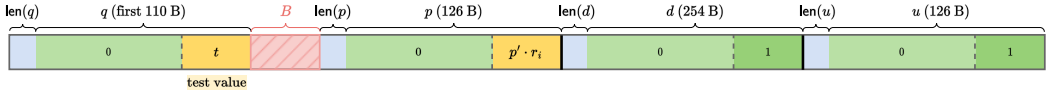

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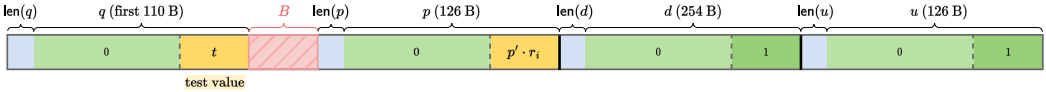

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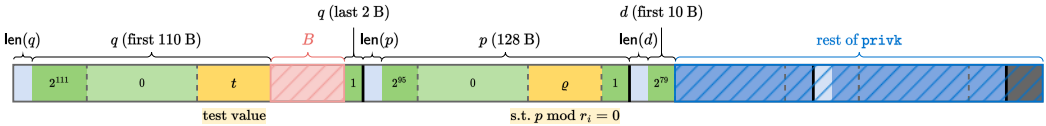

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for $\mathsf{bytelen}(\mathtt{m}) = 256$,
this means $\perp_{00} \iff \mathtt{m}[1] = 00$

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The variety of errors used demonstrates the fragility of the system

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- Recover `privk` using only 2 login attempts (vs. 512 of [BHP23] and 6 of [RH23])

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  - Remove the ECB encryption oracle
  - Replace the low-level crypto/bigint library
- Upgrade of clients in March 2023
- MEGA awarded a bug bounty

Discussion

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Cryptanalysis of protocols "in the wild" is needed to achieve the adoption of more secure and formally analysed cryptographic solutions in practice

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See more details in ia.cr/2023/329

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Thank you for your attention. Any questions?

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