WhatsUpp with Sender Keys?
Analysis, Improvements and Security Proofs

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Group Messaging

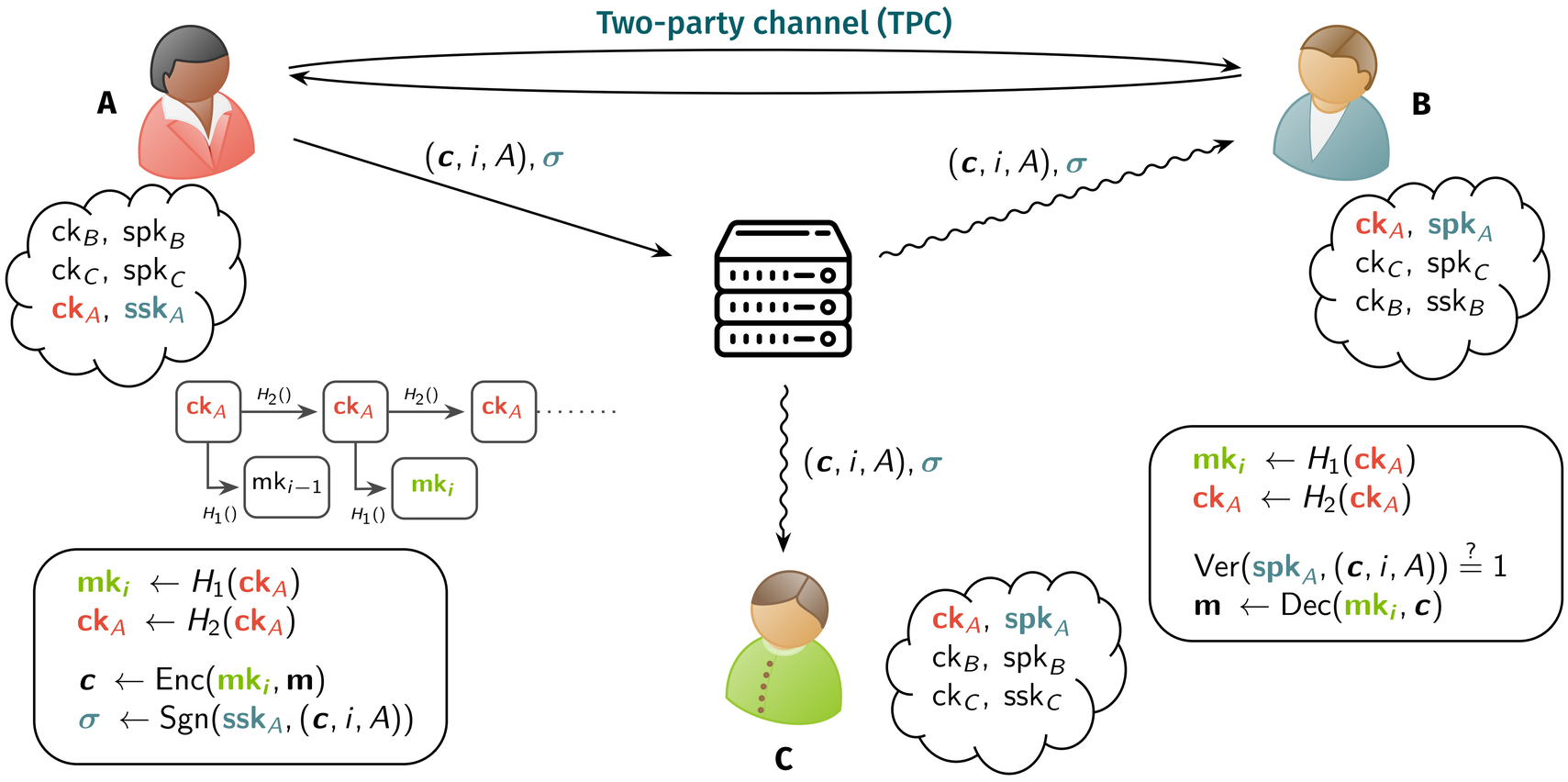
- Widely used messaging protocols claim **security** and **end-to-end encryption**. But this is **vague** and often **misleading**... 🔐
- For example, Telegram has no end-to-end encryption (in groups). 🤯
- **Sender Keys** is the protocol used in **WhatsApp and Signal** for groups; surprisingly, no formal analysis exists! 😮
- Known group messaging models [1, 2, 3] do not suit Sender Keys. 😢
- ***Can we formalise Sender Keys in a meaningful security model?*** 🤔

What is group messaging?

Secure, correct, asynchronous algorithms for:

- **Send:** message m encrypted $\longrightarrow C$.
- **Recv:** retrieve ciphertext C, decrypt it, and obtain the ID of the sender $\longrightarrow (\mathsf{m}, ID)$.
- **Exec:** execute a group change: *create*, *add*, *remove* or *update* $\longrightarrow T$.
- **Proc:** process T and apply group change.

Sender Keys



- Members share a *sender key* $\mathsf{SK} = (\mathsf{ck}, \mathsf{spk})$ with everyone.
- spk is a public signature key, ck is a symmetric chain key.
- **A sends m:** Encrypts using a message key mk_i deterministically derived from ck_A.

  Ciphertext $\boldsymbol{c}$ signed (σ) with spk_A.
- **B & C receive:** Server broadcasts. B & C derive mk_i, check signature σ and decrypt $\boldsymbol{c}$.
- **Key agreement** over "secure" two-party channels between pairs.

  New keys sent after **updates, adds, and removes.**

Results

New formalism for groups with two-party channels ⇒ **Game-based security model with active adversary** ⇓ **Formal specification of Sender Keys** ⇐ **Security proof, limitations, improved protocol**

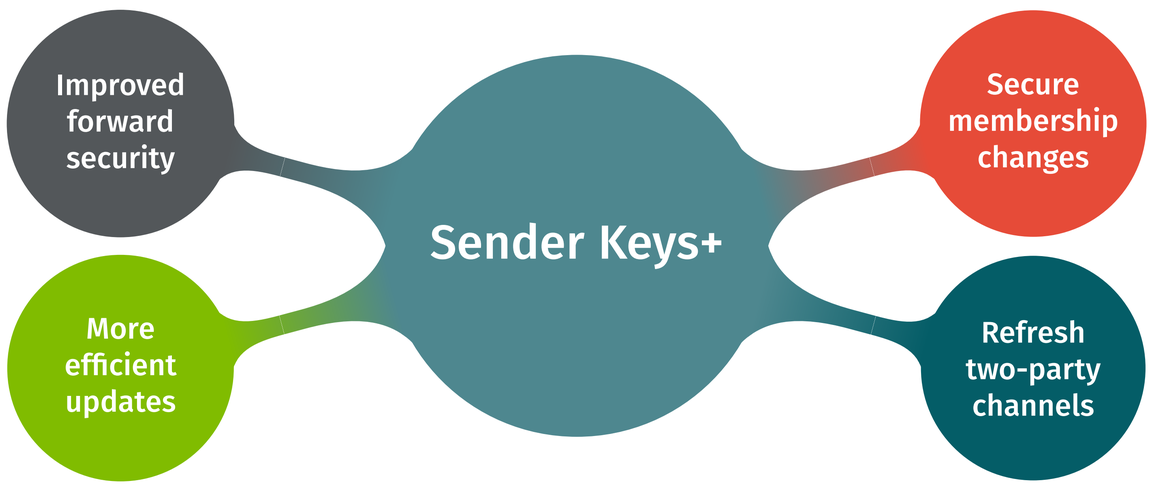
Theorem 1: Sender Keys is secure in our model - but with respect to a heavily restricted adversary.

Observations:

- Central server can fully control group membership.
- Stale two-party channels may leak sent keys.
- Forward security is sub-optimal.

Theorem 2: Our proposed Sender Keys+ is more efficient and secure w.r.t. a stronger adversary!

Our Improved Protocol



References

[1] Joël Alwen, Sandro Coretti, Yevgeniy Dodis, and Yiannis Tselekounis. *Security analysis and improvements for the IETF MLS standard for group messaging*. CRYPTO, 2020.

[2] Joël Alwen, Sandro Coretti, Yevgeniy Dodis, and Yiannis Tselekounis. *Modular Design of Secure Group Messaging Protocols and the Security of MLS*. CCS, 2021.

[3] David Balbás, Daniel Collins, and Serge Vaudenay. *Cryptographic administration for secure group messaging*. USENIX Security, 2023.

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