WhatsUpp with Sender Keys?

Analysis, Improvements and Security Proofs

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- **MLS**: Lots of theoretical analysis. *Secure, efficient, complex.*
- **Sender Keys**: WhatsApp, Signal. *No formal analysis so far.*

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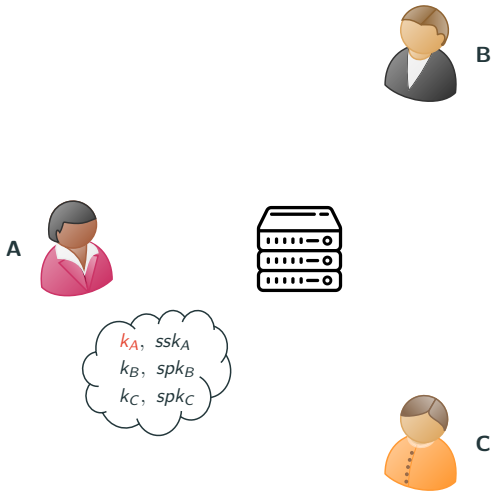

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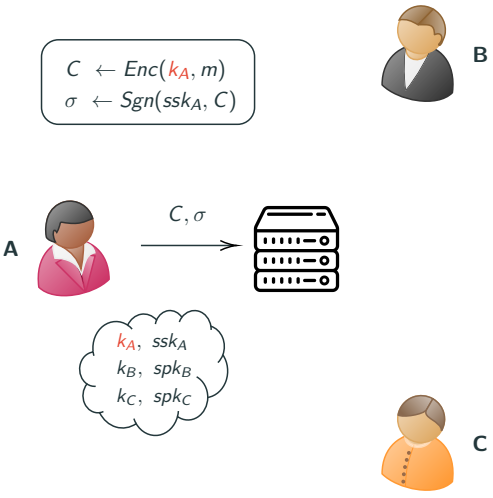

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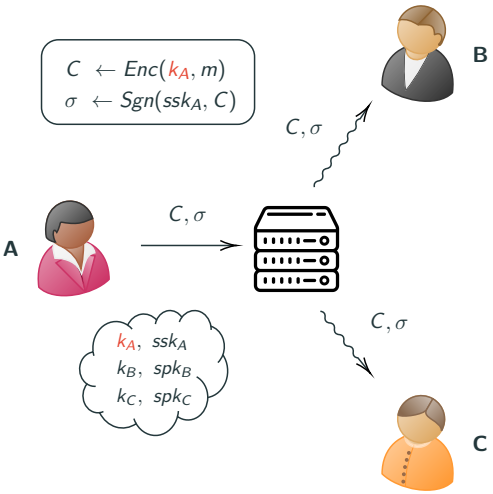

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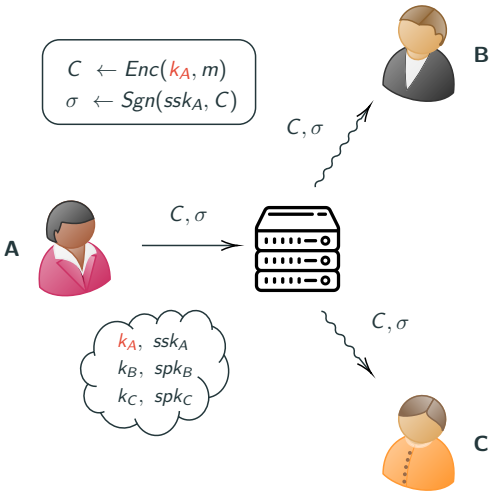
- Parties use *two-party messaging* to share fresh key material.



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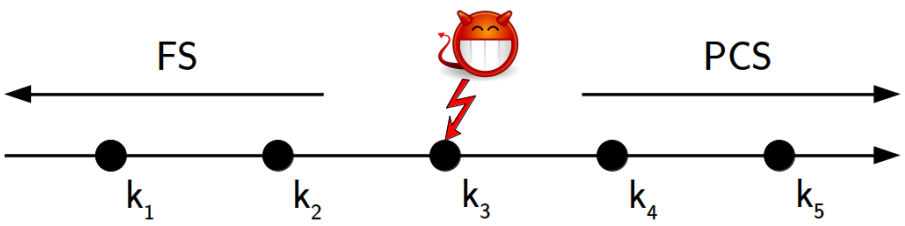
- **Post-Compromise Security (PCS):** *future* messages secret a key refresh.



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What are its main **deficiencies**, and how can we address them *efficiently*?

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Concurrent work [Albrecht, Dowling, Jones, S&P 2024] formalizes Matrix, similar conclusions.

Protocol and Syntax

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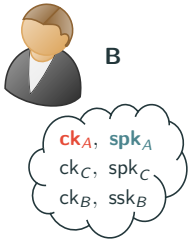

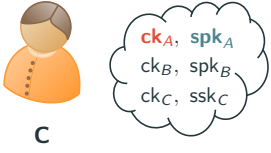

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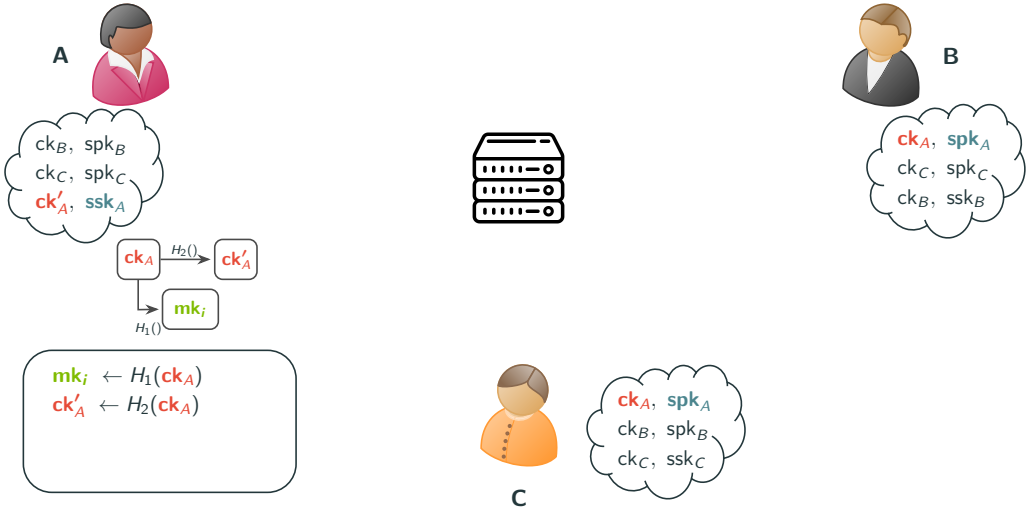

Sender Keys: Send & Recv

A

$(\boldsymbol{c}, i, A), \sigma$

B

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$\mathsf{ck}_C,\ \mathsf{spk}_C$
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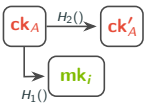

$\mathsf{mk}_i \leftarrow H_1(\mathsf{ck}_A)$
$\mathsf{ck}'_A \leftarrow H_2(\mathsf{ck}_A)$
$\boldsymbol{c} \leftarrow \mathsf{Enc}(\mathsf{mk}_i, \mathbf{m})$
$\sigma \leftarrow \mathsf{Sgn}(\mathsf{ssk}_A, (\boldsymbol{c}, i, A))$

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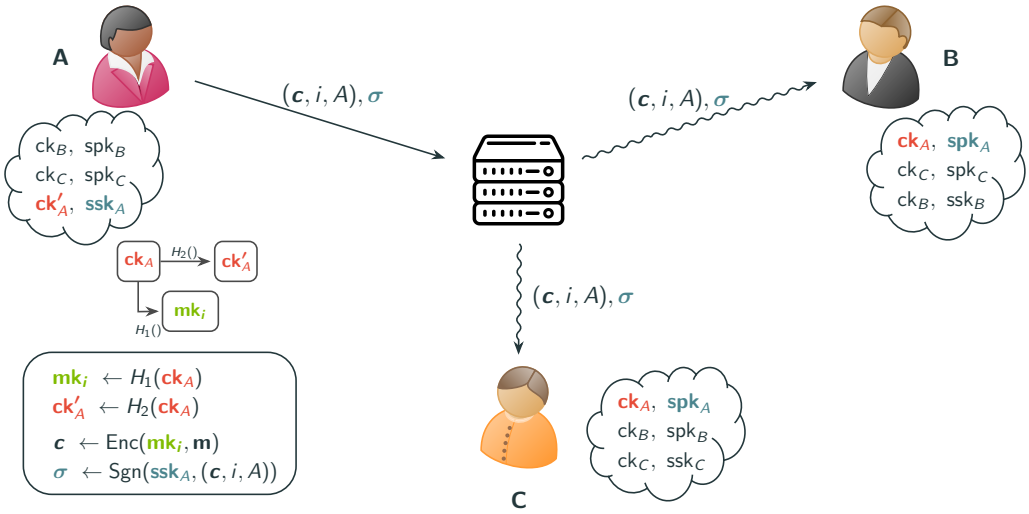

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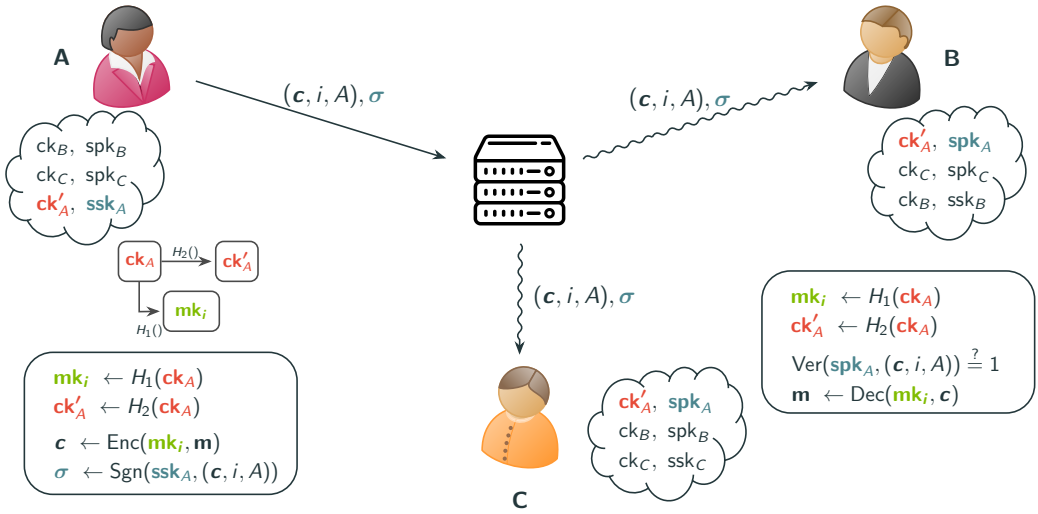

Two-Party Channels

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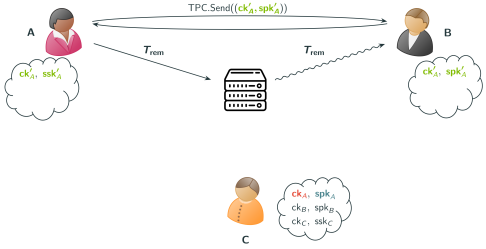

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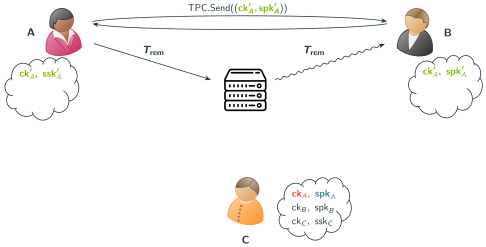

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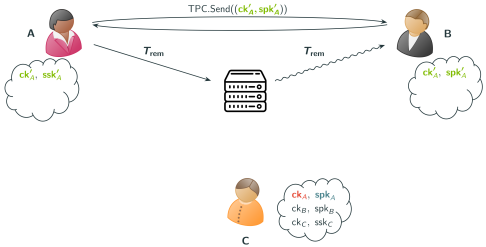

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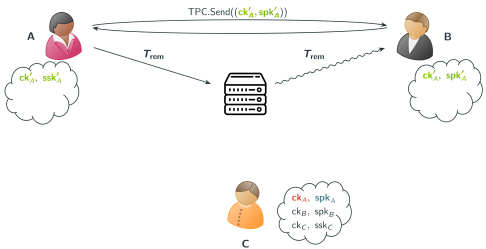
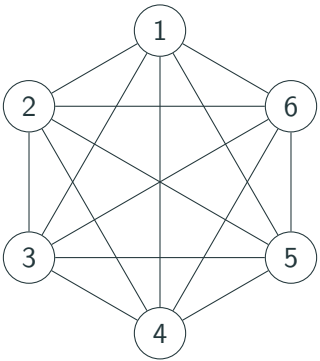


Modelling 2PC

We model *two-party channels as a primitive* 2PC.

Two-Party Channels

Two-party channels only refresh (i.e. achieve PCS) if users interact.



However, some two-party chats are often stale...

Proving Security

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Oracles:

- $\texttt{Create}(ID, \boldsymbol{IDs})$
- $\texttt{Challenge}(ID, \mathrm{m}_0, \mathrm{m}_1)$
- $\texttt{Send}(ID, \mathrm{m})$
- $\texttt{Receive}(ID, C)$
- $\texttt{Add}/\texttt{Remove}(ID, ID')$
- $\texttt{Update}(ID)$
- $\texttt{Deliver}(ID, T)$
- $\texttt{Expose}(ID)$

Main theorem

Security of Sender Keys (informal)

Assume

- SymEnc is a IND-CPA symmetric encryption scheme.
- Sig is a SUF-CMA signature scheme.
- H is a PRG.
- 2PC is a 2PC-IND$_\Delta$ two-party channels scheme for PCS bound $\Delta > 0$.

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Conclusion: The core of the protocol has *no fundamental flaws*. But it still presents some drawbacks.

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We propose and formalize **Sender Keys+** *as a practical, improved alternative*!

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Can be prevented with a MAC.

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- **Solution:** *sign control messages*!

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- Matrix uses Sender Keys but does not ratchet symmetric keys.

Final Remarks

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Thank you!

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