WhatsUpp with Sender Keys?

Analysis, Improvements and Security Proofs

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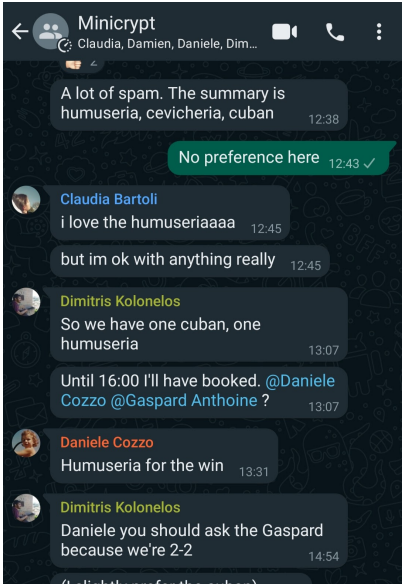
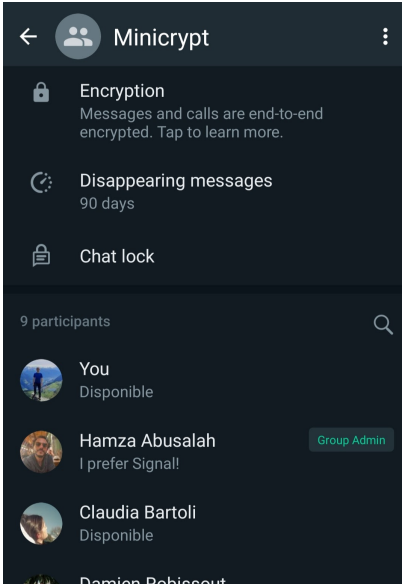
Group Messaging





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

Sender Keys

- Sender Keys is a **simple, efficient** group messaging protocol used in WhatsApp, Signal, Matrix...

B

A

C

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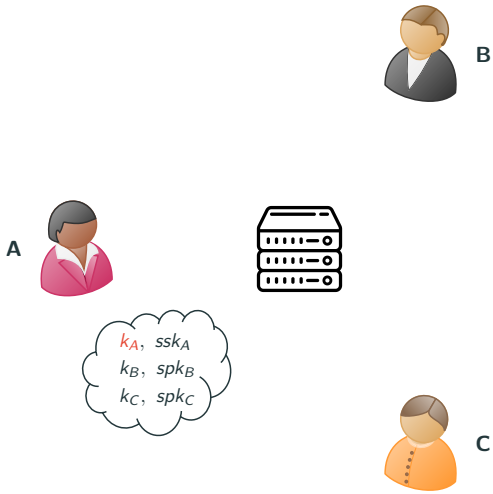

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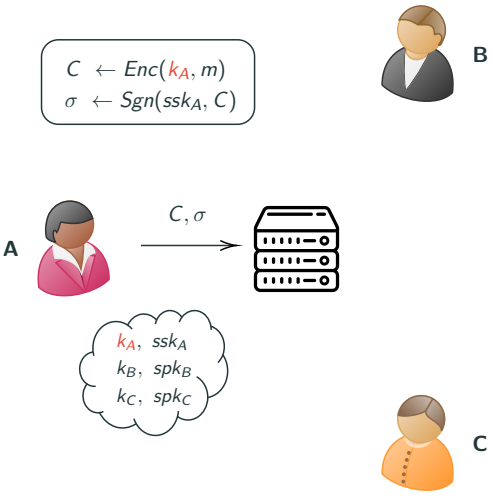

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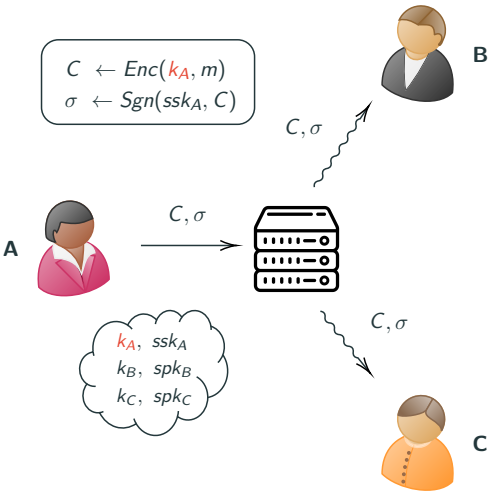

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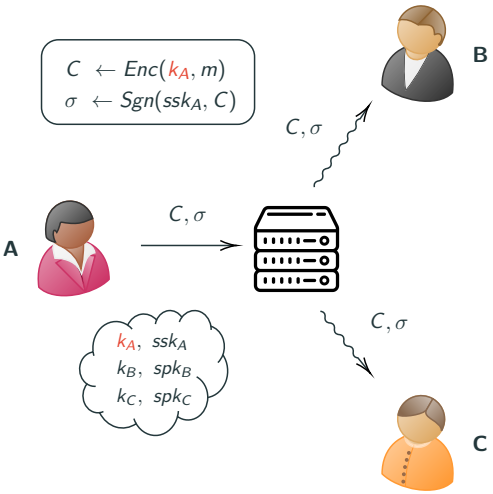
- Parties use *two-party messaging* to share fresh key material.



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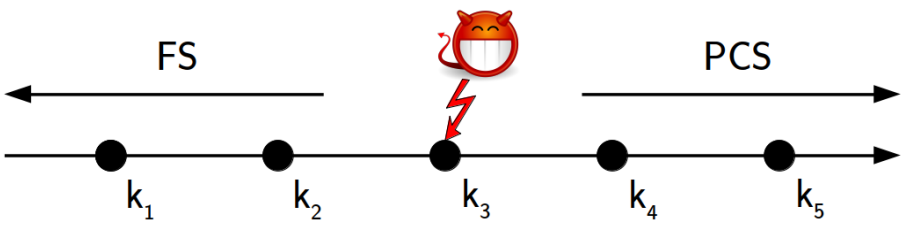
- **Post-Compromise Security (PCS):** *future* messages secret a key refresh.



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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

Syntax

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- $T \xleftarrow{\$} \mathit{Exec}(\mathtt{cmd}, \boldsymbol{\mathit{IDs}}, \gamma)$, $\mathtt{cmd} \in \{\mathtt{crt}, \mathtt{add}, \mathtt{rem}, \mathtt{upd}\}$

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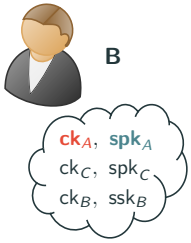
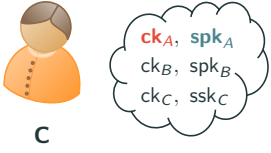
Sender Keys: Send & Recv





Sender Keys: Send & Recv

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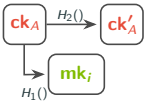
ck_B, spk_B
ck_C, spk_C
ck'_A, ssk_A



$mk_i \leftarrow H_1(ck_A)$
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B

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C

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

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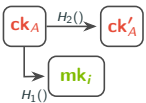

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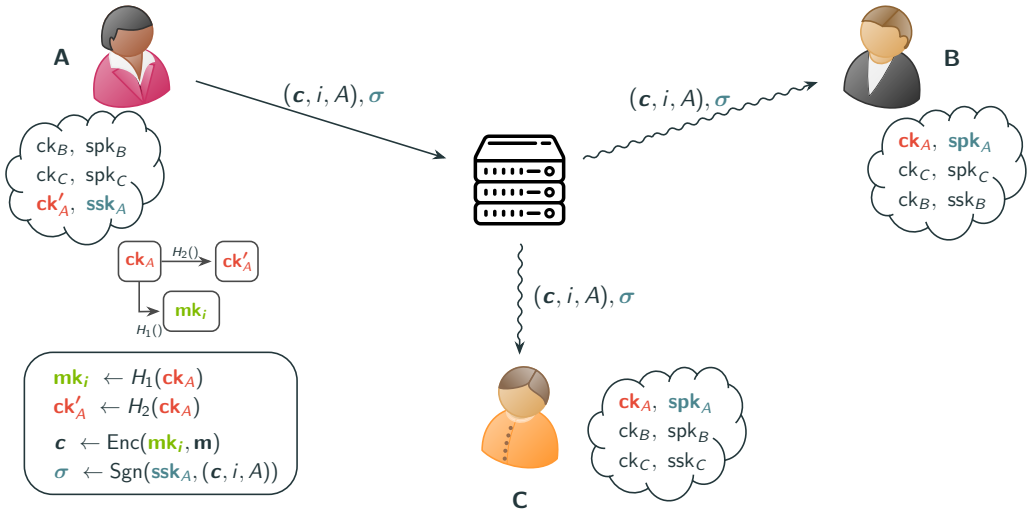

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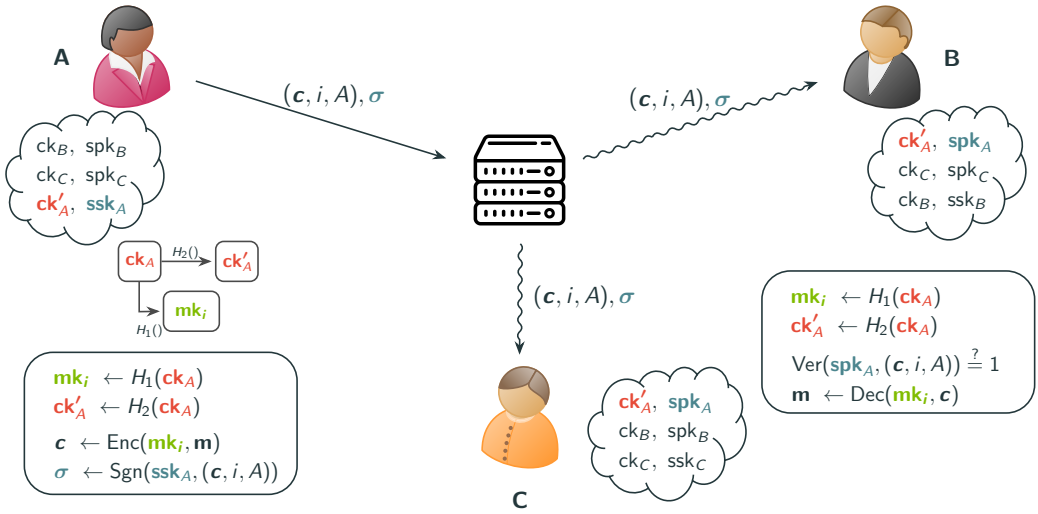

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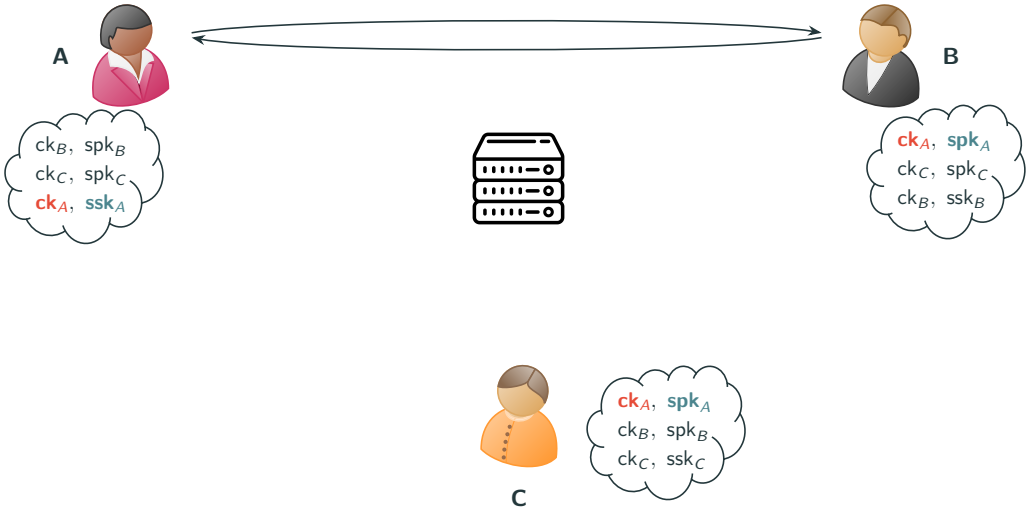

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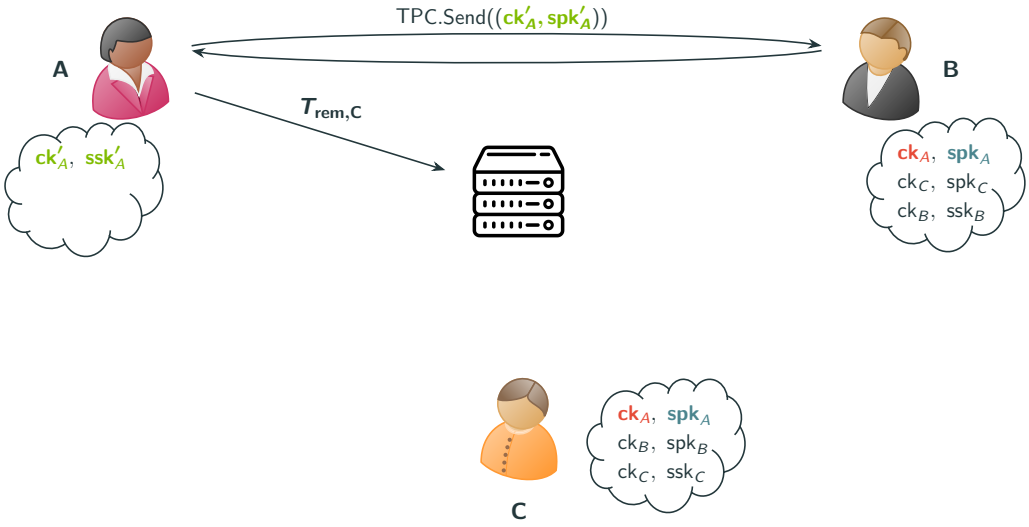

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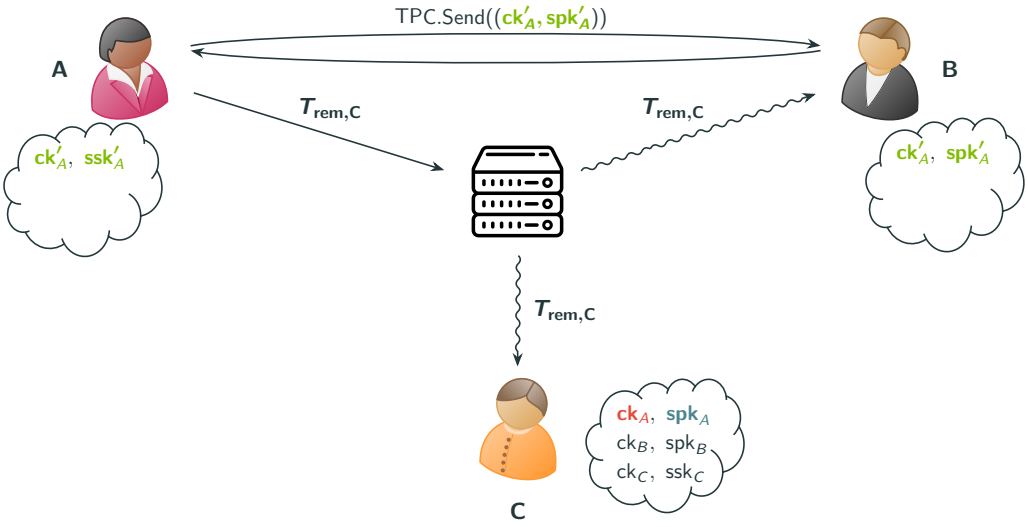
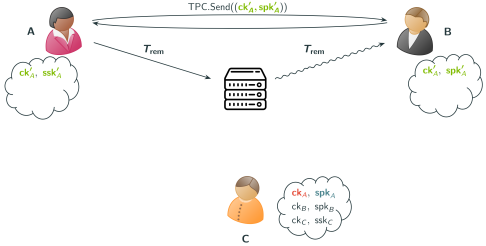


Two-Party Channels

- **If C leaves** (or someone updates):



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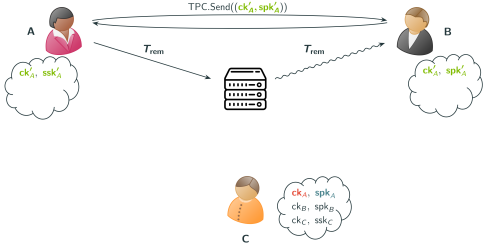

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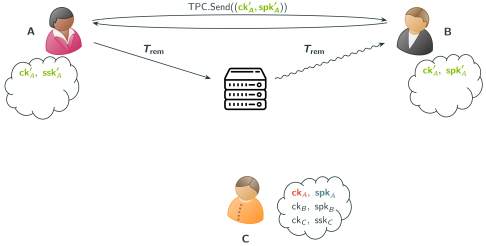

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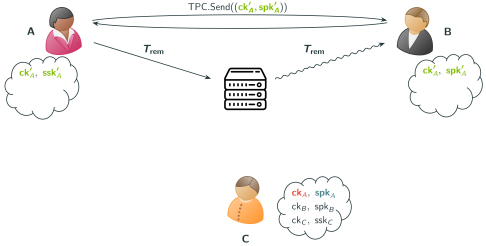
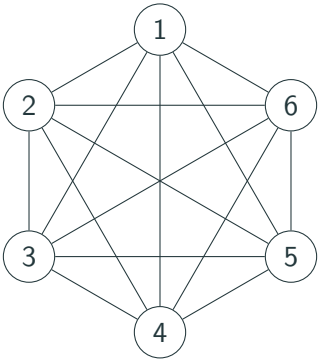


Modelling 2PC

We model *two-party channels as a primitive* 2PC, parametrized by a *PCS bound* Δ.
Δ is the number of messages needed for the channel to heal [ACD19].

Two-Party Channels

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



This can be problematic in practice.

Proving Security

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Oracles:

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

Security

Security of Sender Keys (informal)

Let

- SymEnc a IND-CPA symmetric encryption scheme
- Sig a SUF-CMA signature scheme
- H a PRG.
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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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  - Problem: concurrency; when to delete keys?
- **Solution:** All *keys hashed forward* N times before r is applied + keep track of indices.
  - Can *remove parties efficiently* – $O(n)$ communication.
  - Drawback: signature keys not updated.

Final Remarks

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Thank you!

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