RUHR-UNIVERSITÄT BOCHUM

RUB

On the End-to-End Security of Group Chats

Real World Crypto 2018

2018-01-10

Horst Görtz Institute for IT Security
Chair for Network and Data Security
Paul Rösler, Christian Mainka, Jörg Schwenk

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Or:

Why what ☎ is doing is 👍

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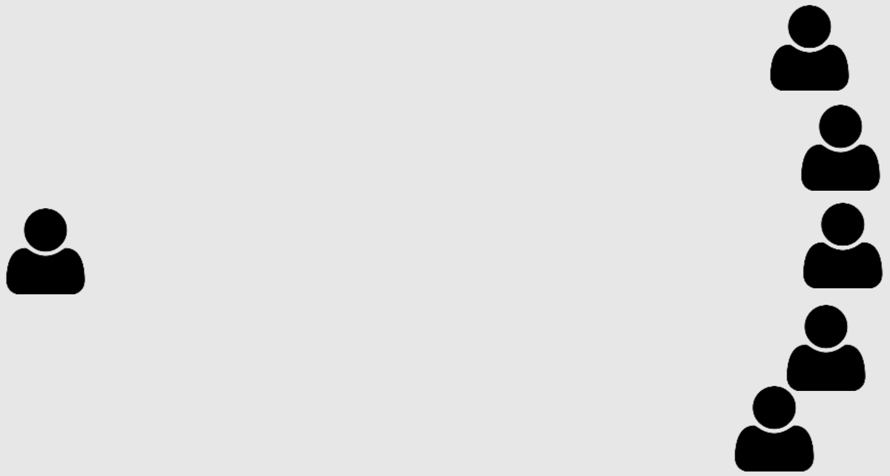
Why what 📞 is doing is 👎 (in 👥)

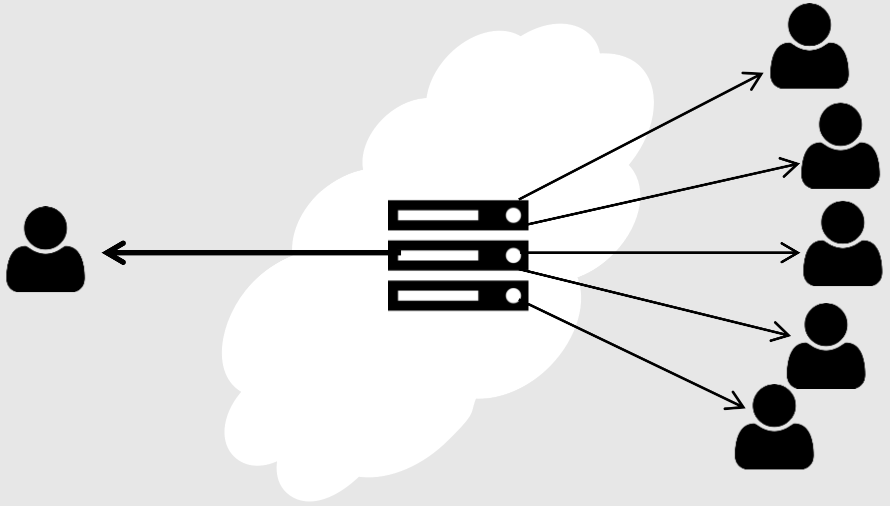
Secure Group Instant Messaging: End-to-End

- Dynamic group of users



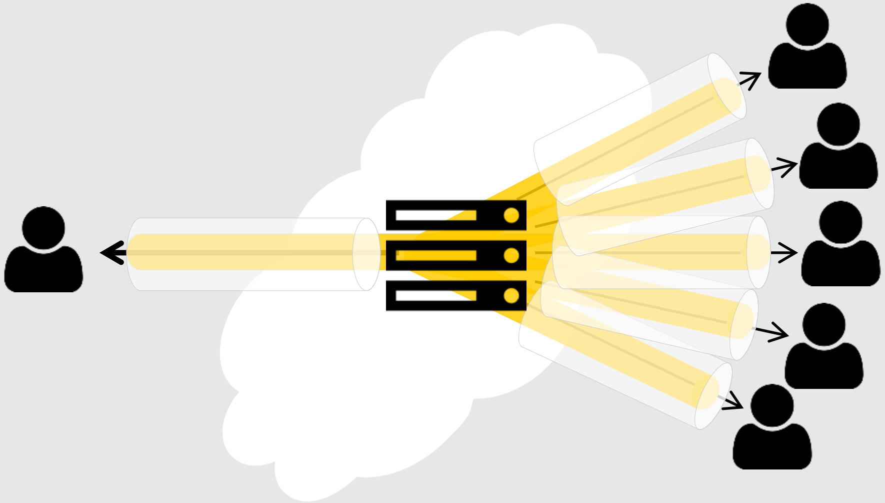
Secure Group Instant Messaging: End-to-End

- Dynamic group of users
- One central server



Secure Group Instant Messaging: End-to-End

- Dynamic group of users
- One central server
- End-to-end protection
  within protected transport layer
- Server potentially malicious



Agenda

- Security Model
- Protocol Overview and Weaknesses
  - Signal
  - WhatsApp
  - (Threema)
- Problems and Solutions
  - Traceable Delivery
  - Closeness

Secure Group Instant Messaging: Two Parties

Confidentiality

- Message Confidentiality

Integrity

- Message Authentication } Two Parties } Groups

Secure Group Instant Messaging: Two Parties

Confidentiality

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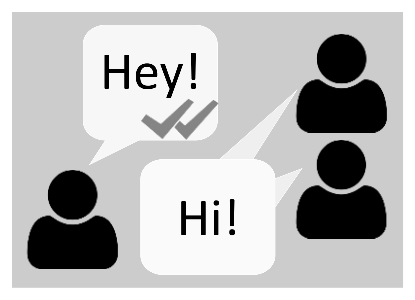
- Message Authentication
- No Duplication
- **Traceable Delivery**

Two Parties

Groups

“Only successful delivery is acknowledged”



Secure Group Instant Messaging: Groups

Confidentiality

- Message Confidentiality
- **Closeness**

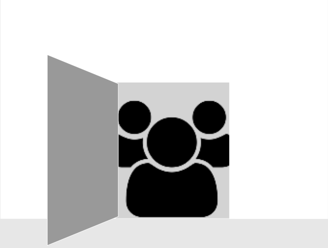
Integrity

- Message Authentication
- No Duplication
- **Traceable Delivery**
- No Creation

Two Parties

Groups

“Only group (admin) decides on membership”



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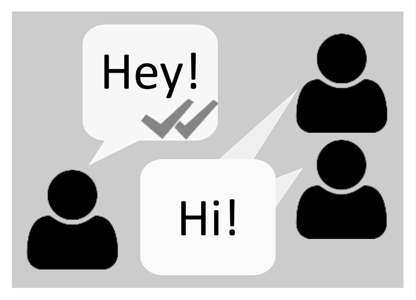
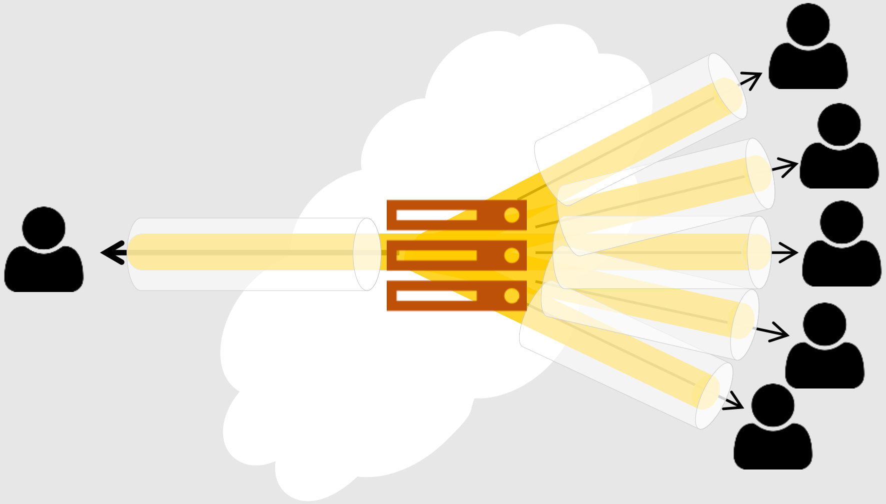


Security Model: Malicious Server

- Malicious Server
  - Can decrypt transport layer protection
  - E.g. IM provider, TLS certificate forger on network, ...



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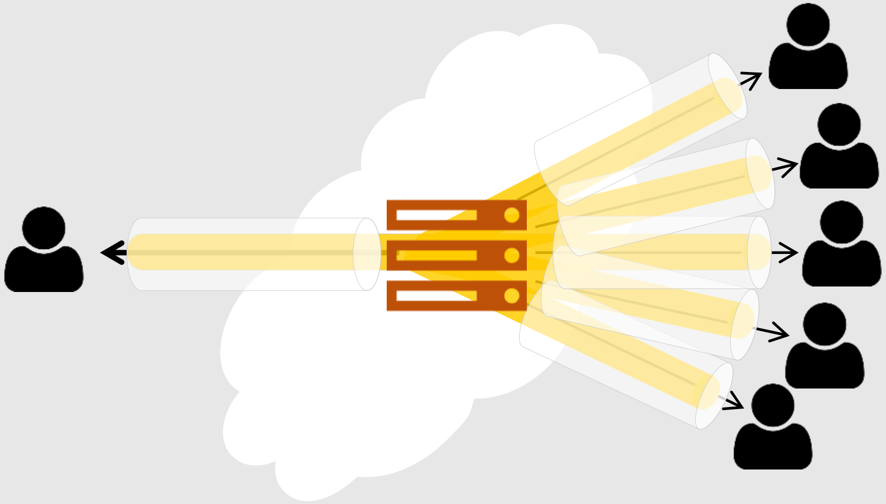
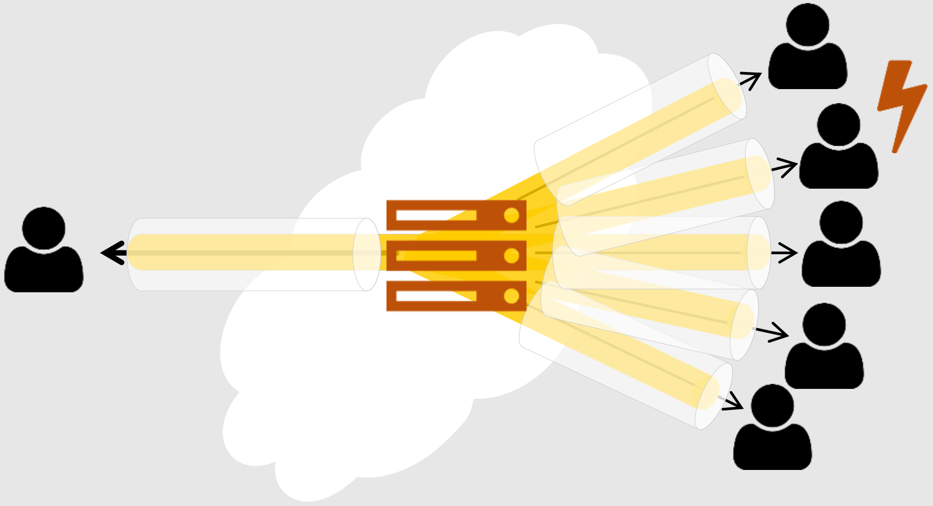


Attackable by	Traceable Delivery	Closeness
💬	☰	?
📞	☰	☰

Security Model: Compromising Attacker

- Compromising Attacker ϟ
  - Access to members’ secrets
  - E.g. access to device, cryptanalysis, …



Attackable by	Traceable Delivery	Closeness
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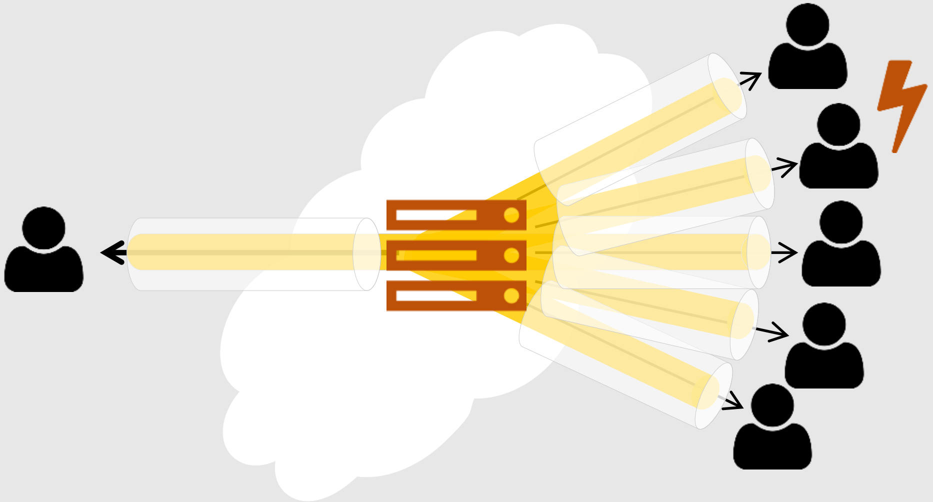
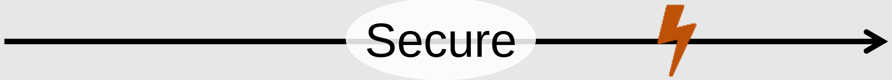
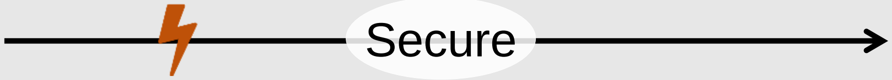


- Advanced Goals:
  - Forward Secrecy



  - Future Secrecy
    (aka Post Compromise Security aka Backward Secrecy)



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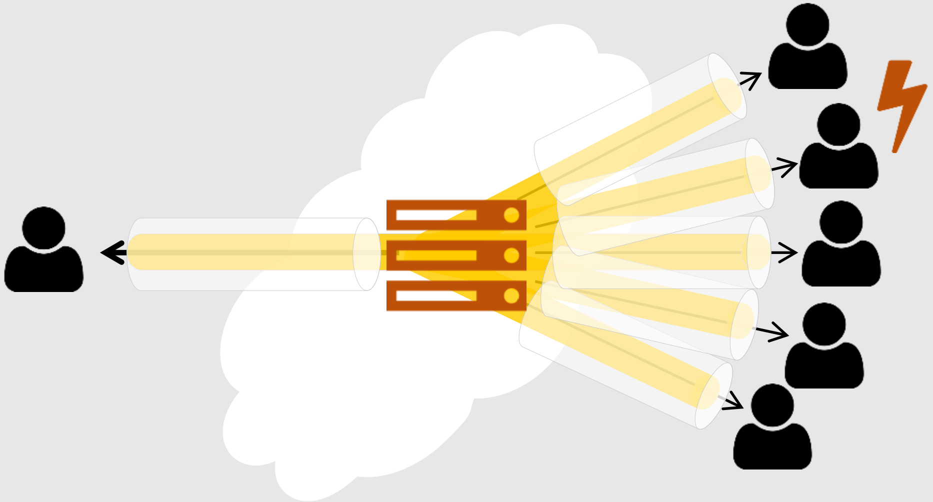

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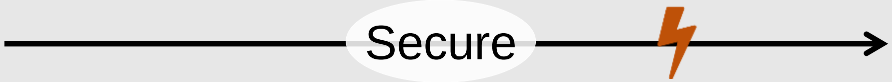

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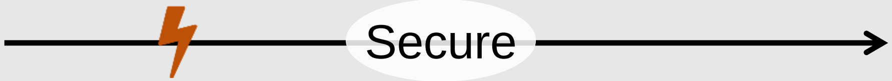


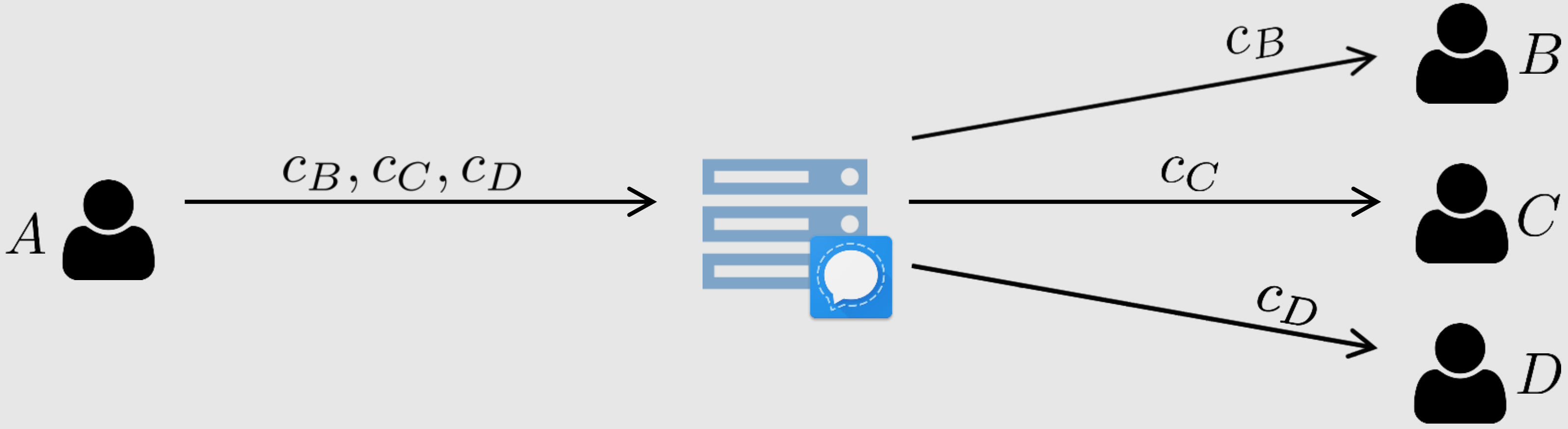
Attackable by	Traceable Delivery	Closeness
💬	🗄	⚡ (Fut. Sec.)
📞	🗄	🗄

Protocol Overview: Signal

- Ciphertexts c (ID static)

$$\forall i \in G \setminus \{A\}\colon$$
$$c_i \leftarrow \mathrm{E}_A(i; ID_G, t, m)$$

$$G = \{A, B, C, D\}$$



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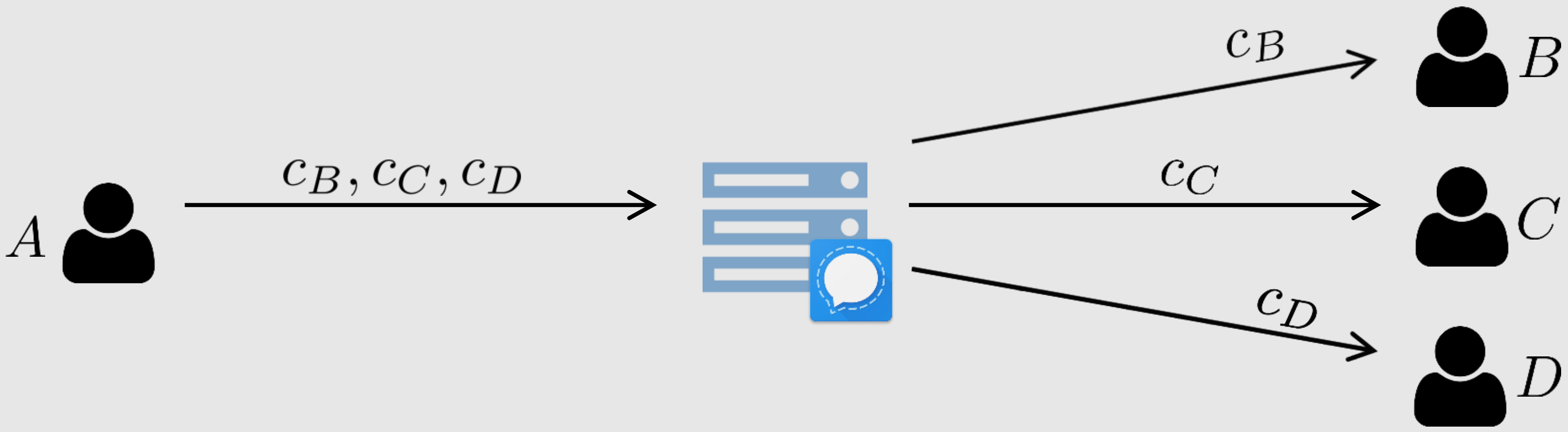

- Forward and future secure key streams of *direct* communication
- Group ID as proof of membership

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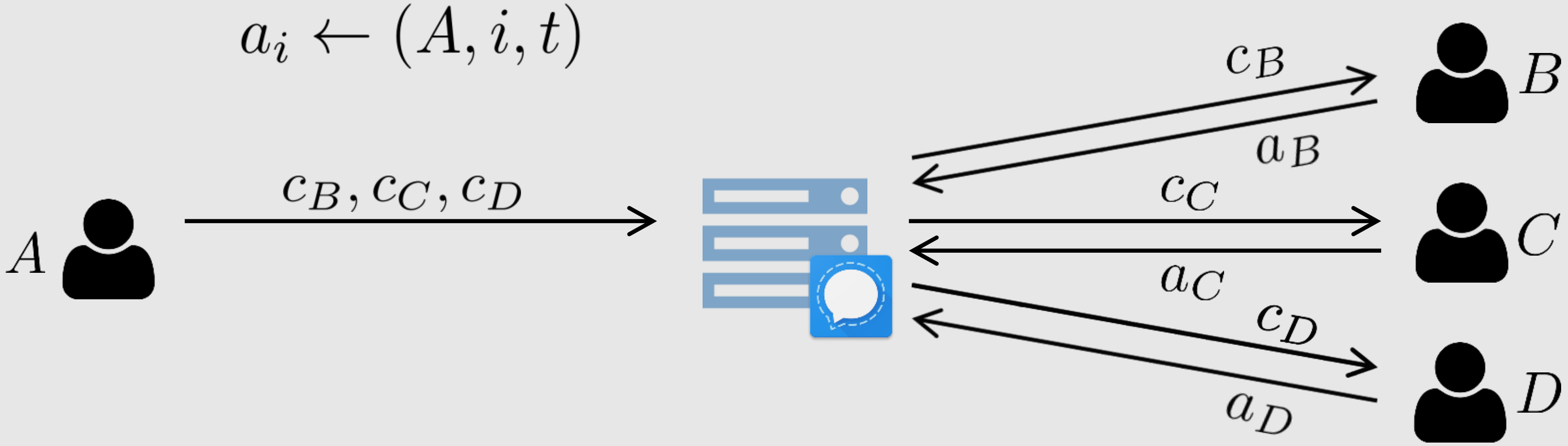

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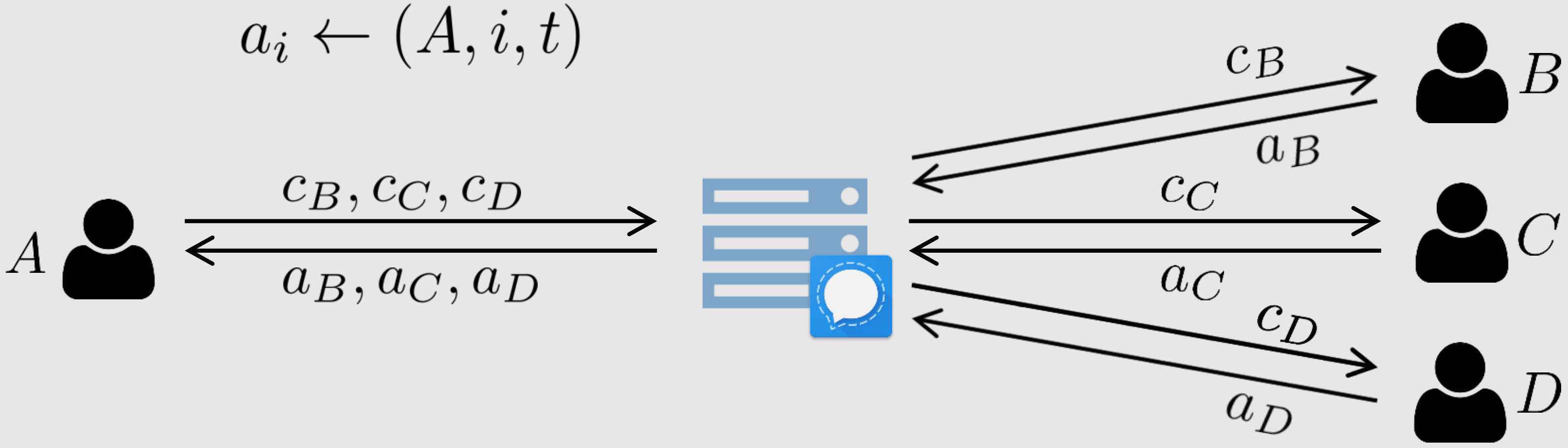

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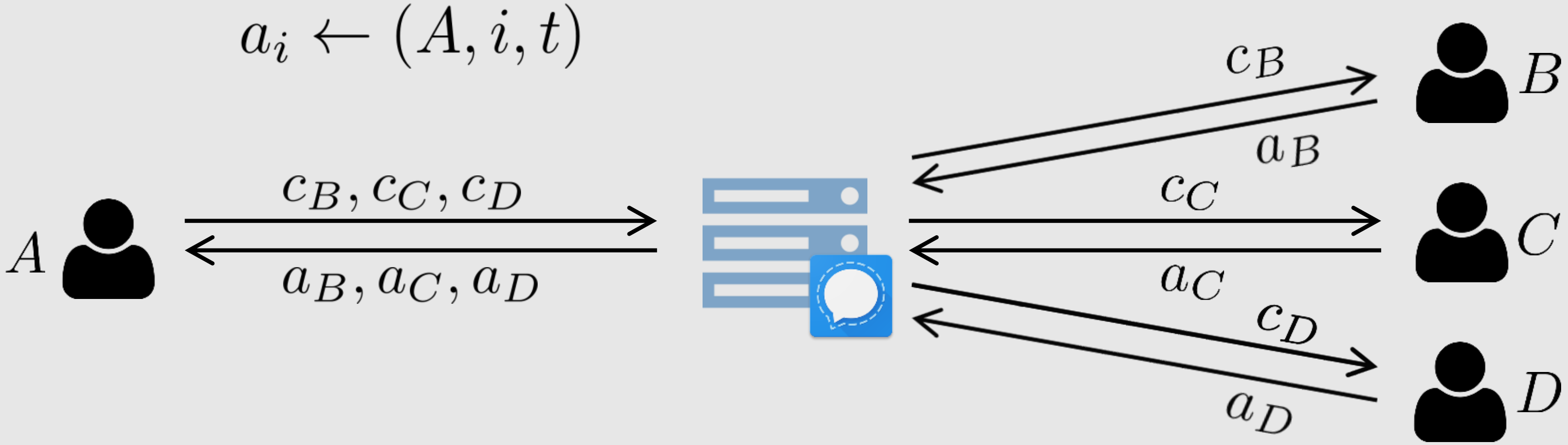

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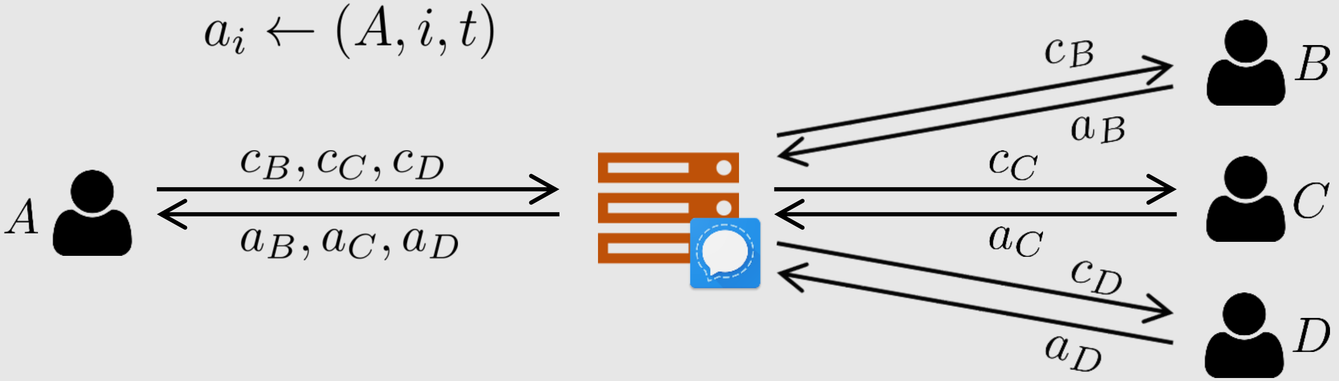

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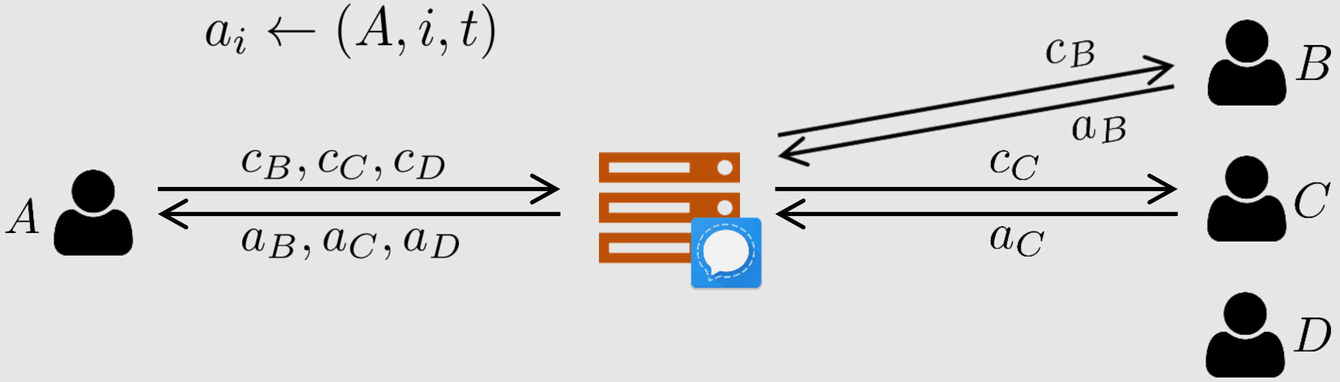

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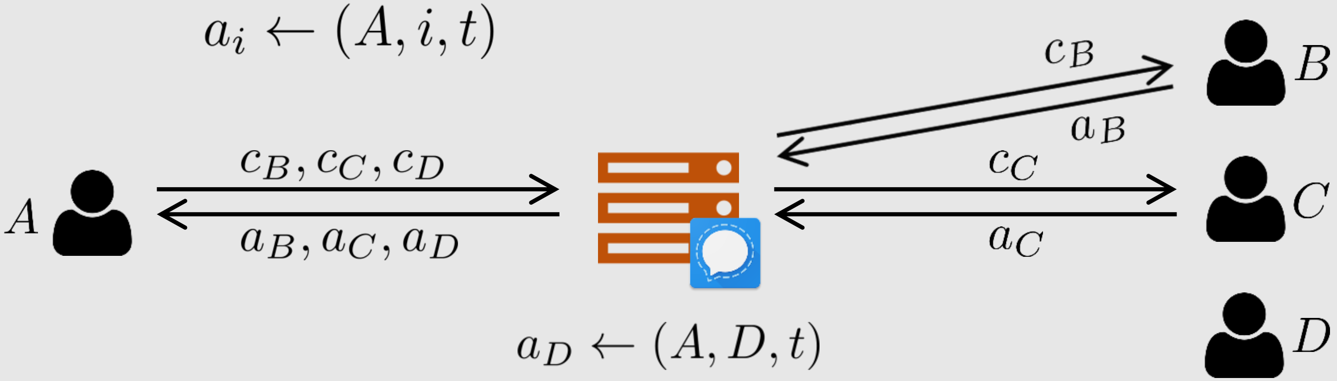

$a_D \leftarrow (A, D, t)$

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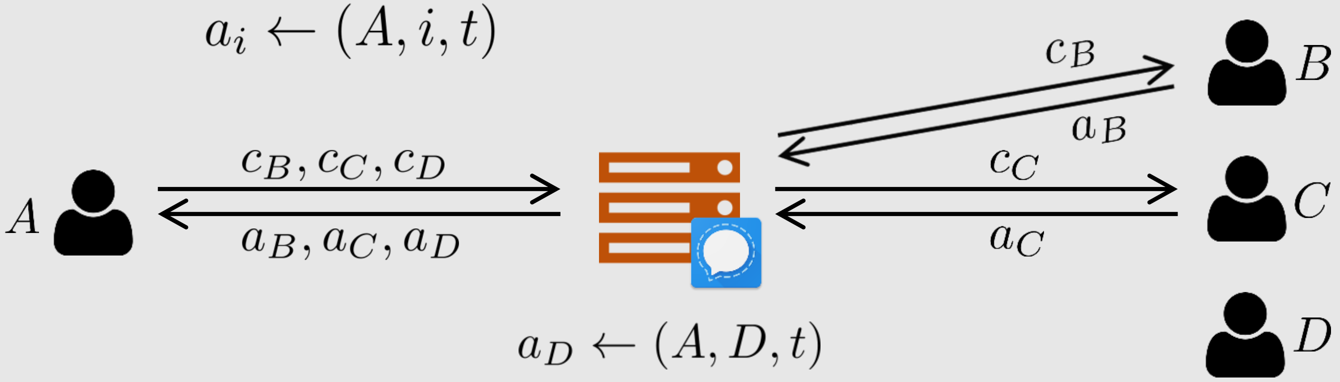

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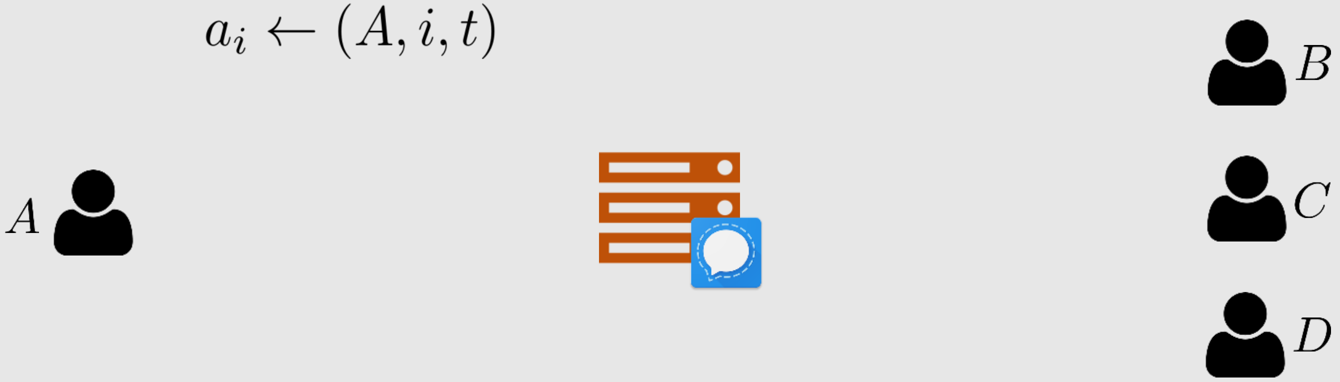

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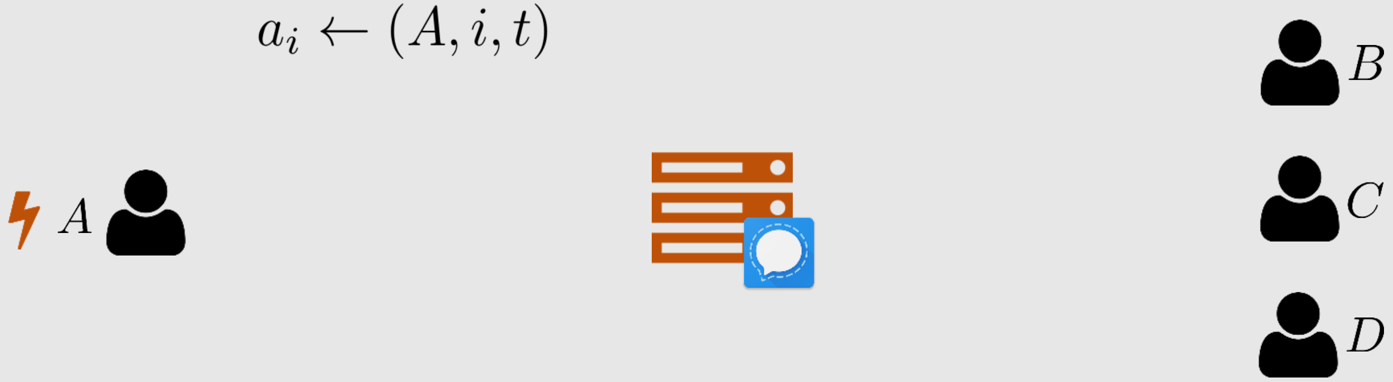

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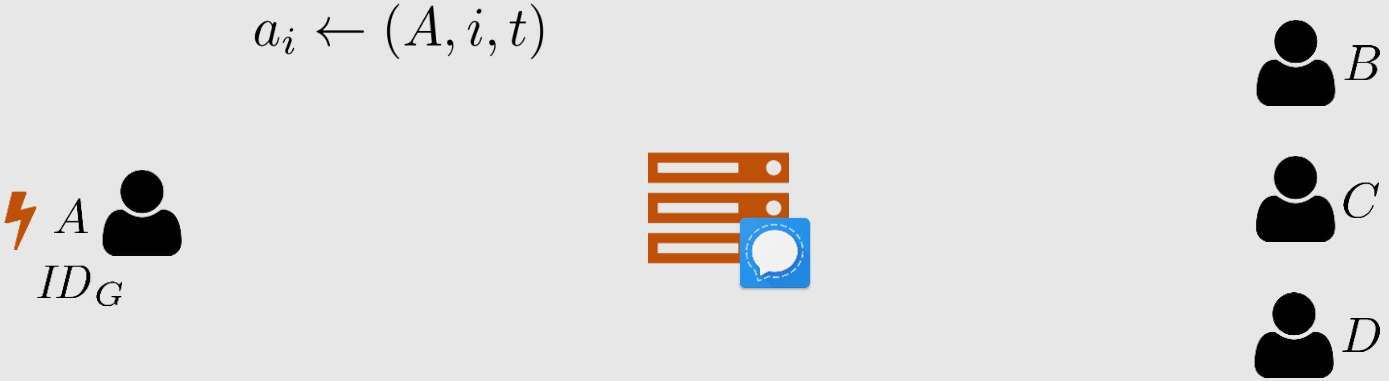

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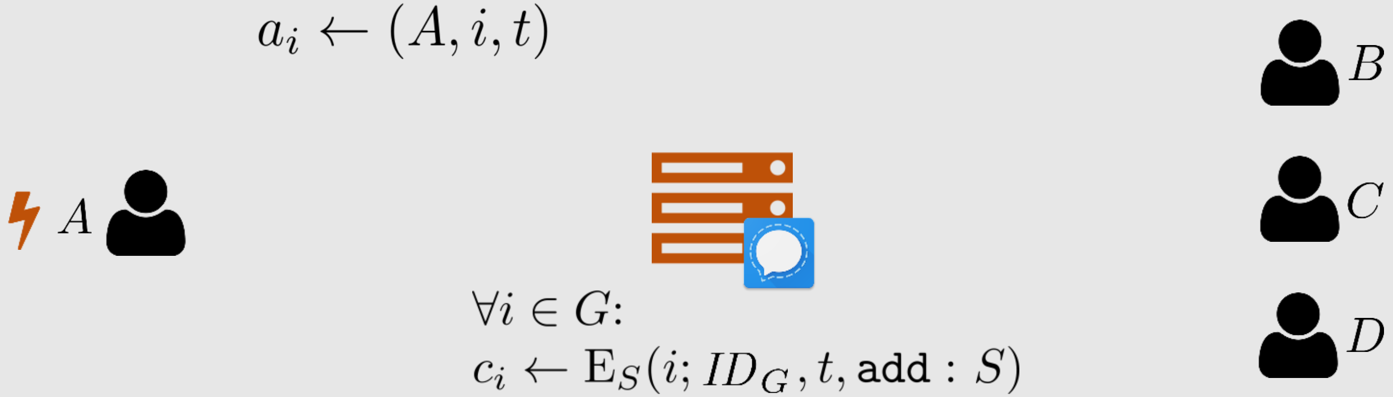

$\forall i \in G$:
$c_i \leftarrow \mathrm{E}_S(i; ID_G, t, \texttt{add}: S)$

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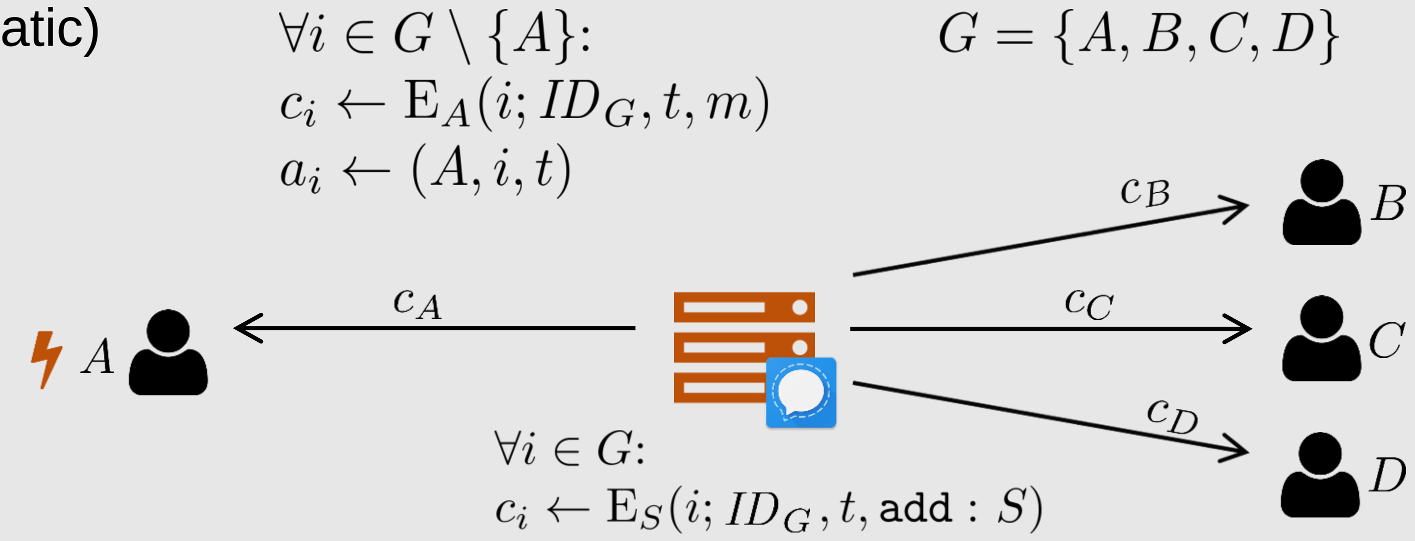
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c_B
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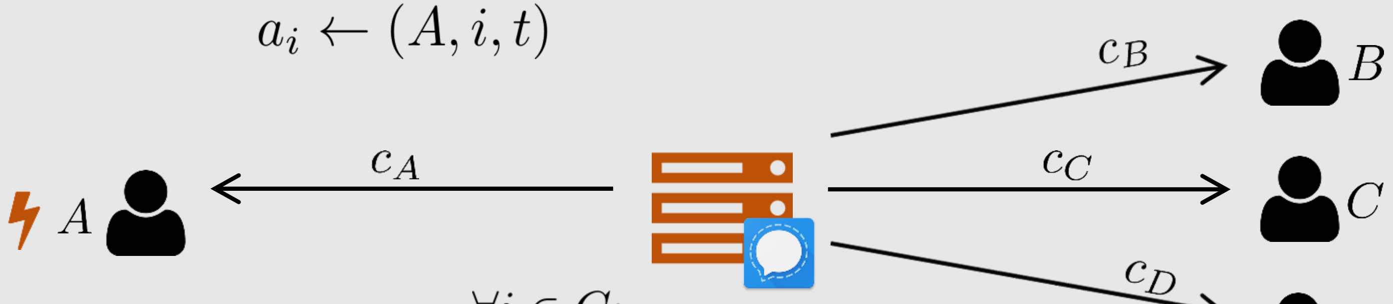

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- Forward and future secure key streams of *direct* communication
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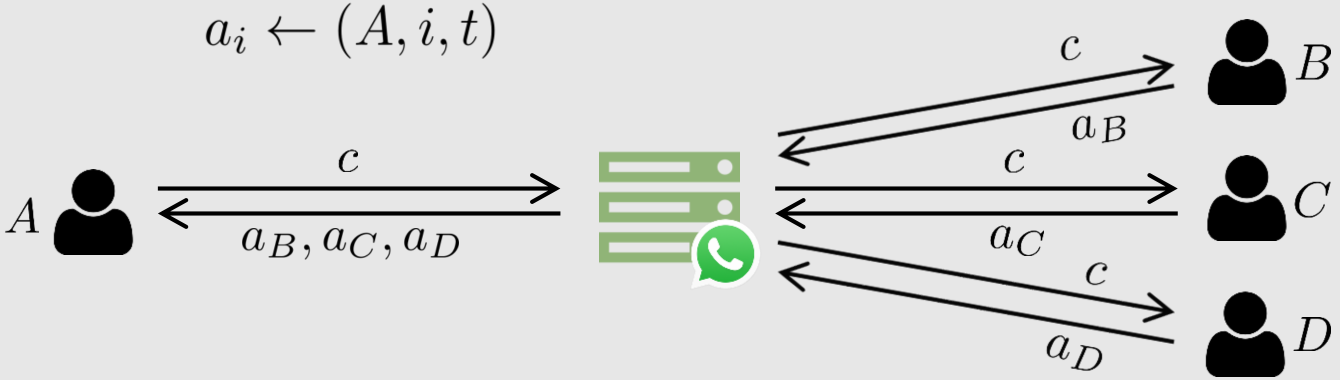
- 🗄 Traceable delivery by ack forgery *
- ⚡ Closeness by using compromised group ID

Protocol Overview: WhatsApp

$$\begin{aligned} &\forall i \in G \setminus \{A\}: \\ &c \leftarrow \mathrm{E}_A(\mathbf{G}; m), t \\ &a_i \leftarrow (A, i, t) \end{aligned}$$

$$G = \{A, B, C, D\}$$

- **Group updates plain via server**



- Forward secure key streams for each group (and sender)

Weaknesses: WhatsApp

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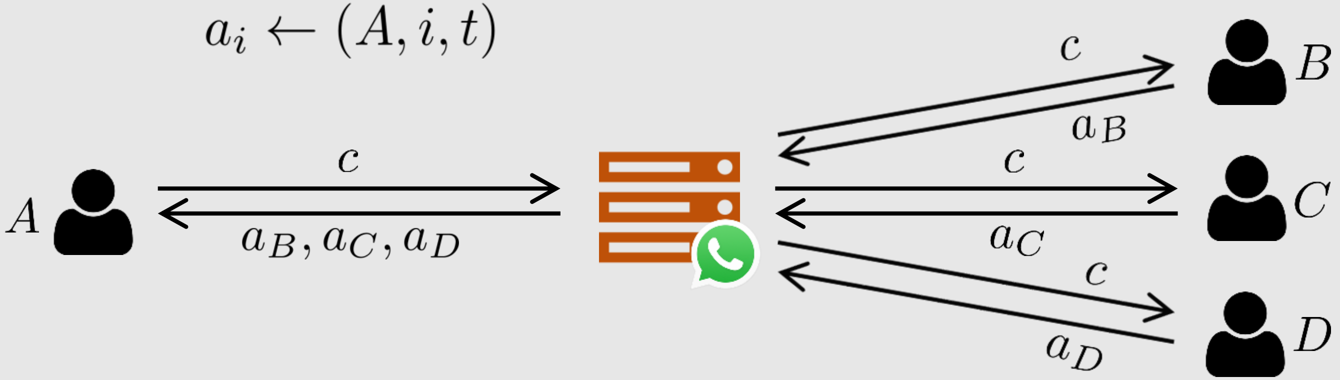

- Forward secure key streams for each group (and sender)

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- Closeness by group update forgery

Problems & Solutions: Traceable Delivery

- Acks are not authenticated

  → Explicit authentication by delivering as content message (AE) or signing

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- * For Signal and WhatsApp with key stream (stateful encryption):
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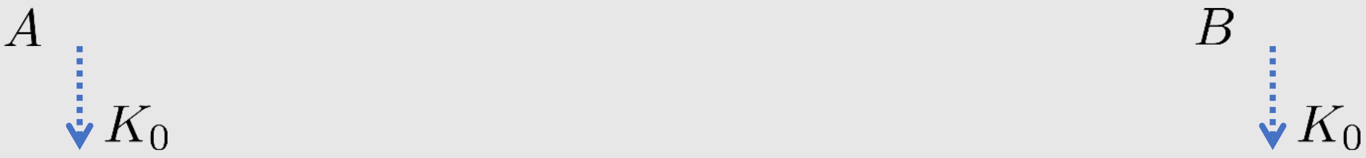

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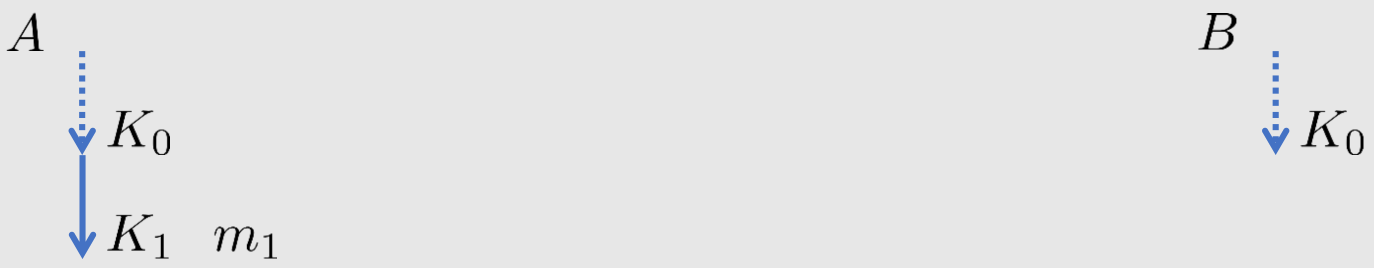

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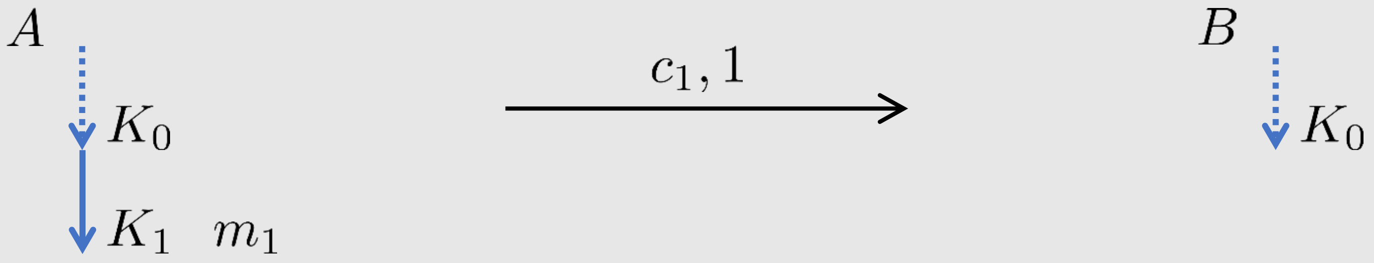

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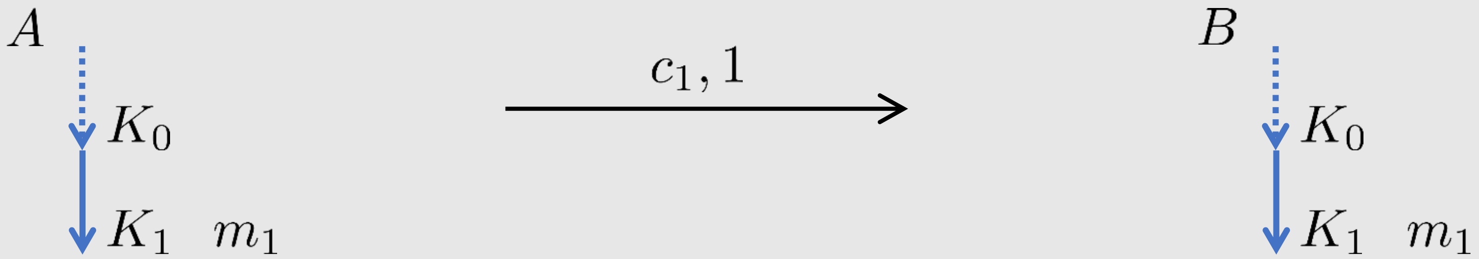

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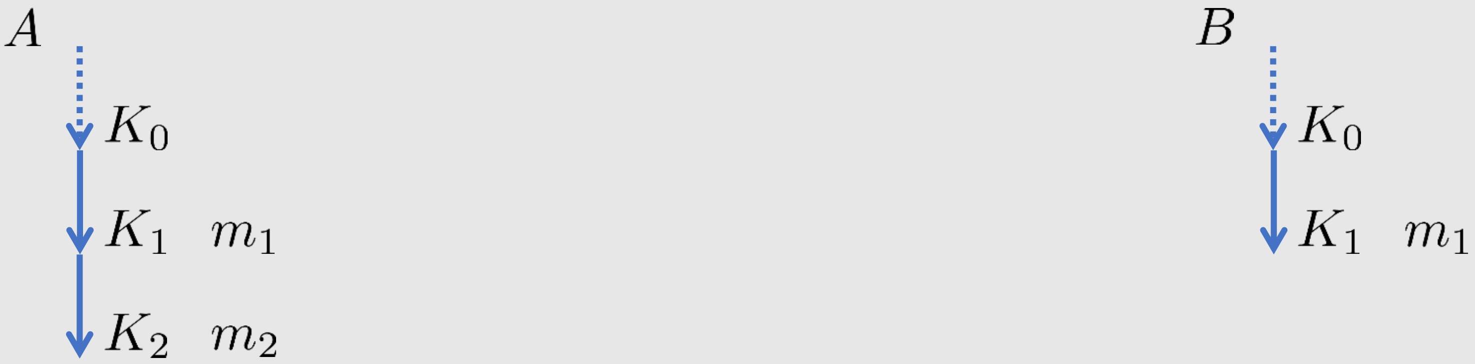

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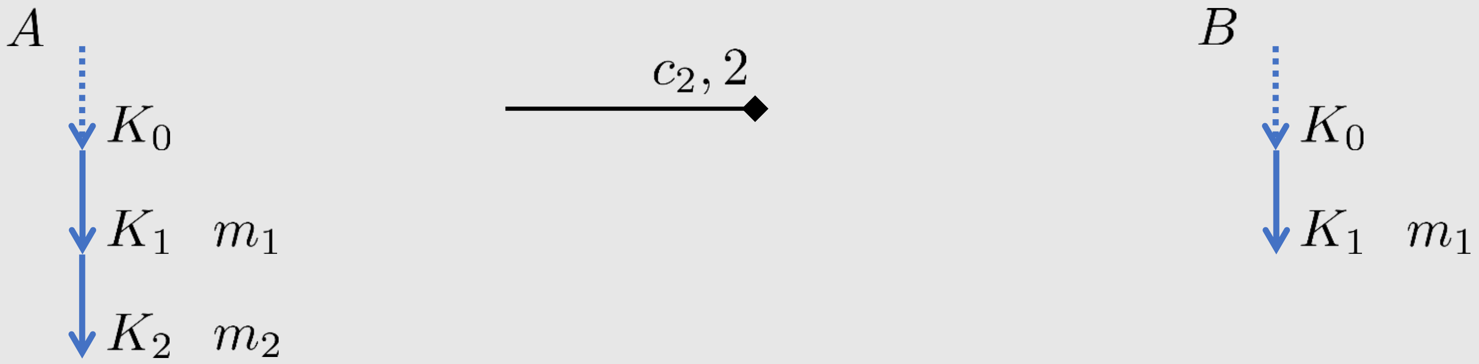

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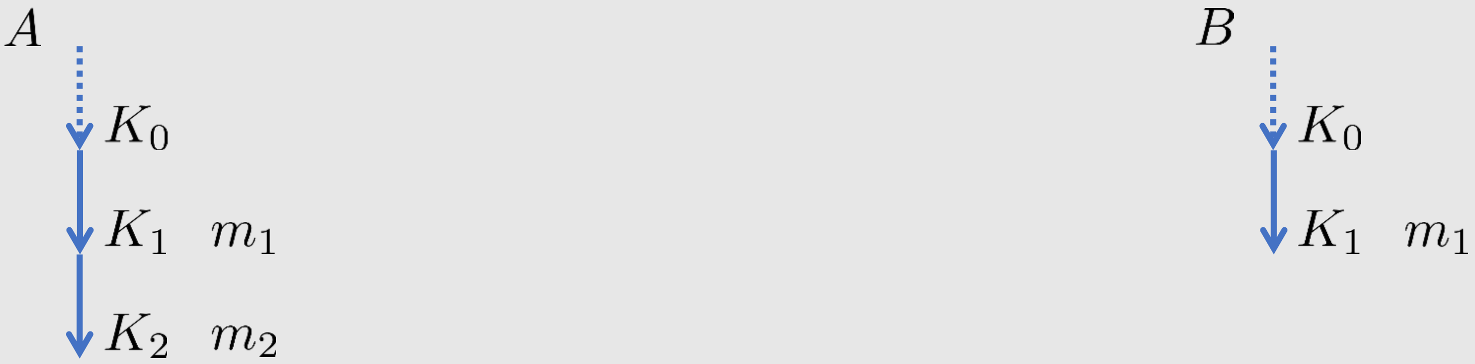

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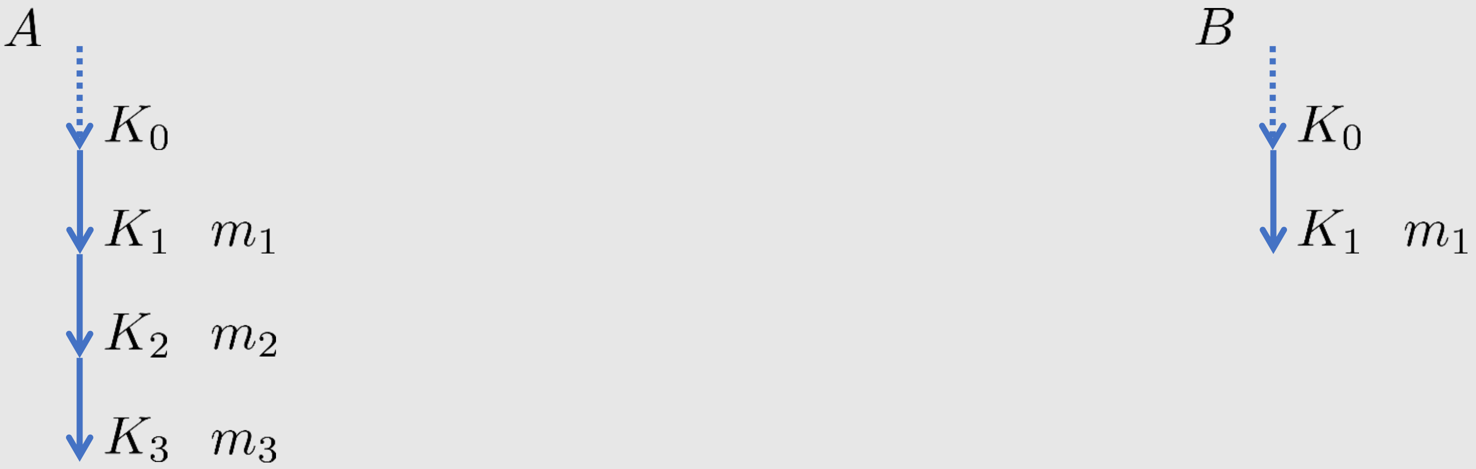

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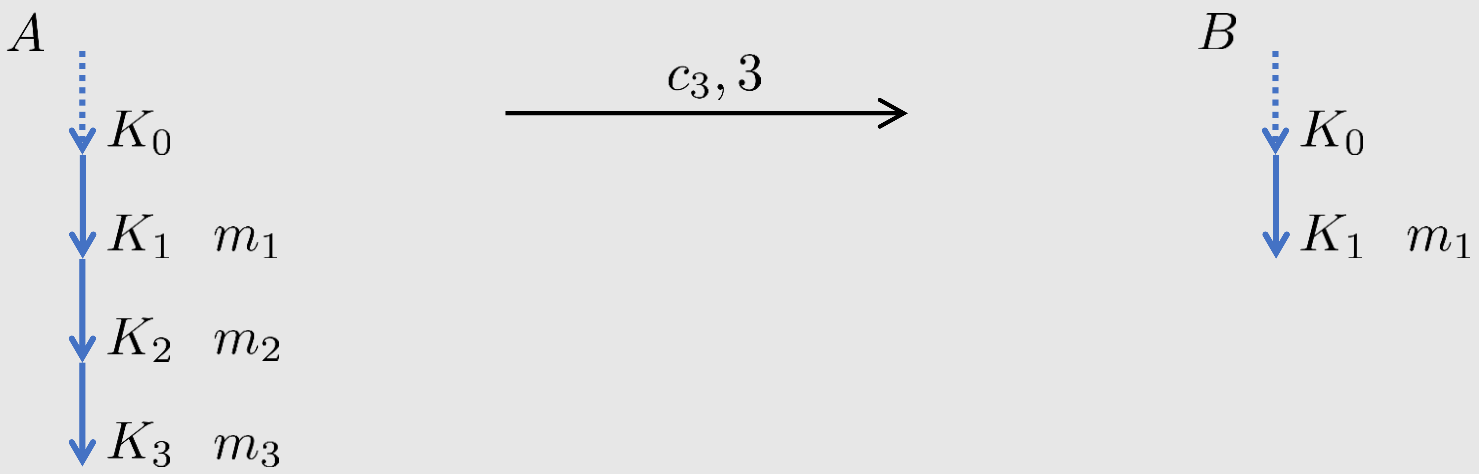

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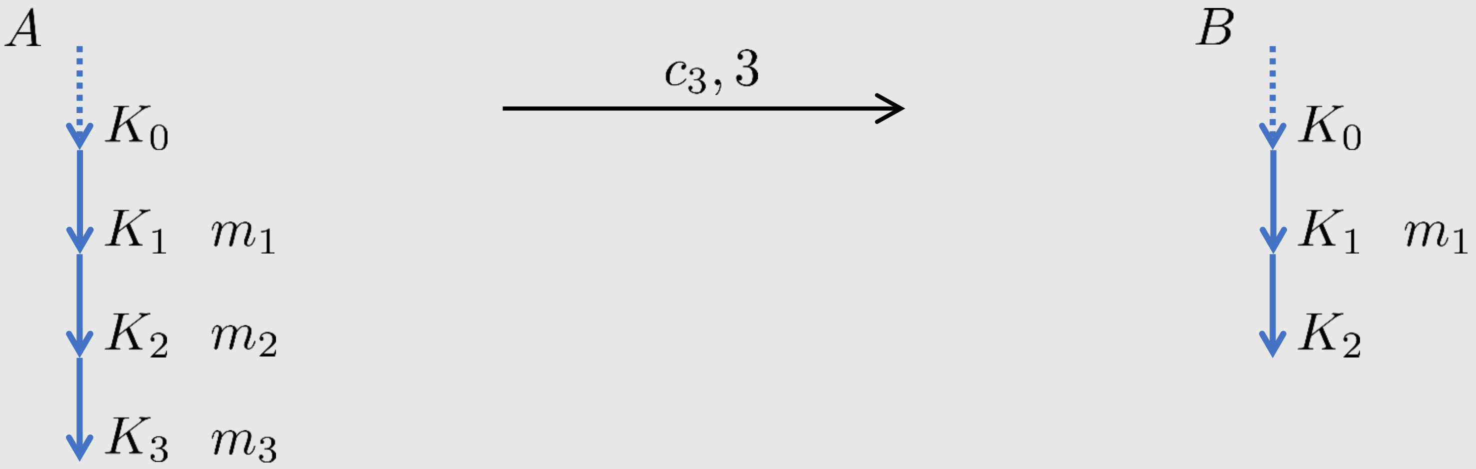

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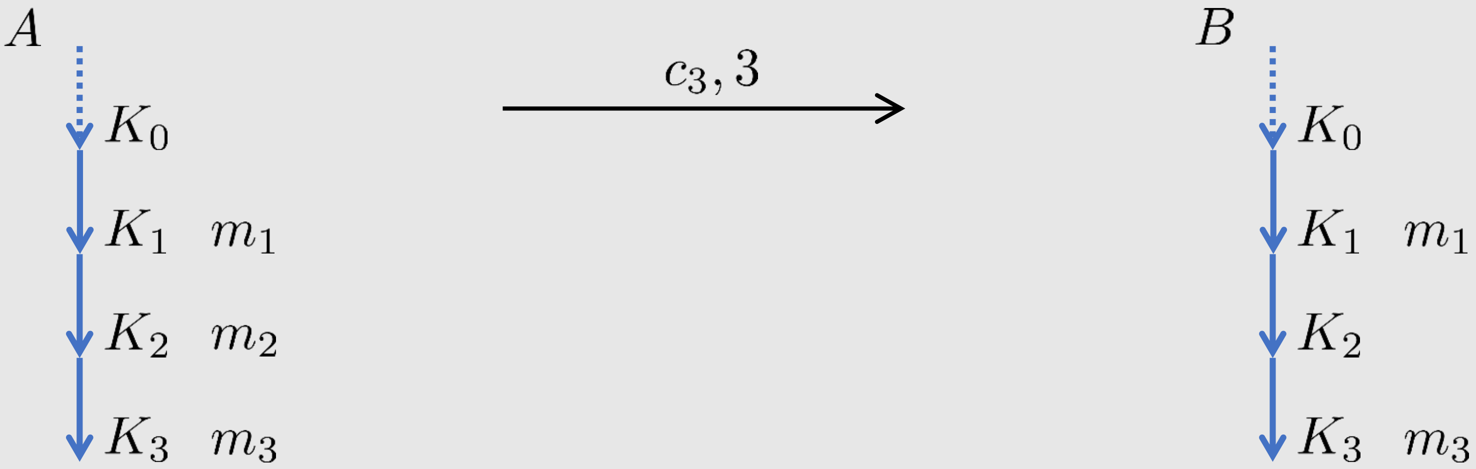

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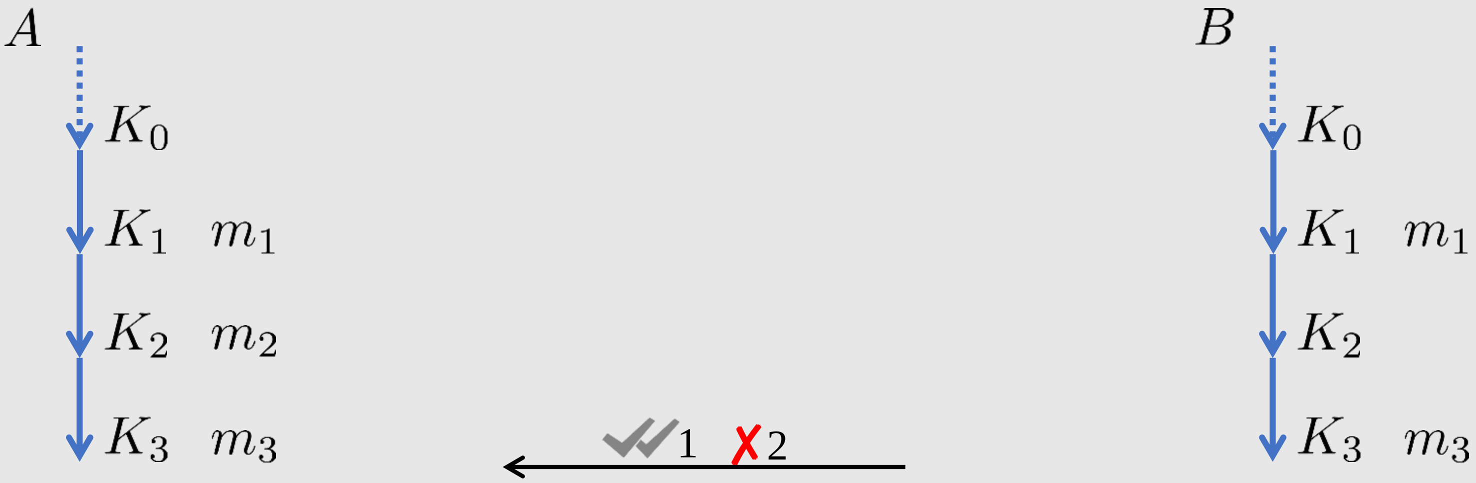
  → Ack newest in order received message (e.g., with content messages)
  → Send negative ack (NACK) on key omission



Problems …: Closeness

Receiving according to …

- Guest list approach
  - WhatsApp: updates sent plain
- Ticket approach
  - Signal: updates accepted if group ID in message

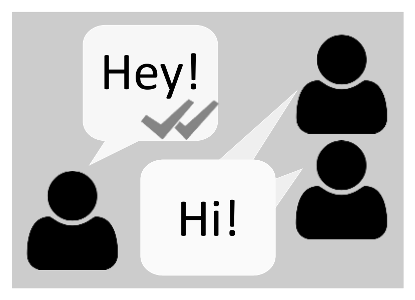
Problems …: Closeness

Receiving according to …

- Guest list approach
  - WhatsApp: updates sent plain
    - Manipulable by server
- Ticket approach
  - Signal: updates accepted if group ID in message
    - Static group ID ⇒ not (future) secure against compromising attacker

… and Solutions: Closeness

- Guest list approach
  - Authentic update messages
  - Causality [MarPoe ePrint ‘17]
    - Not desired: “*reordered, delayed, or lost in normal operation*” (Moxie Marlinspike)
  - At least traceable delivery
- Ticket approach



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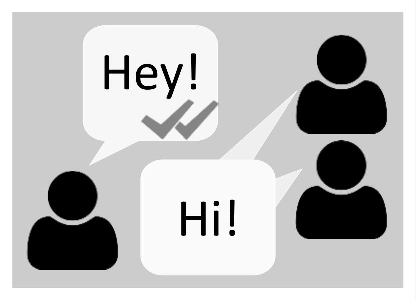
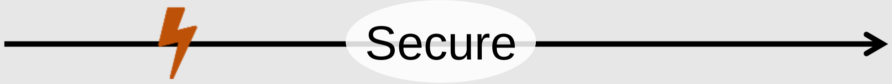
  - At least traceable delivery
  - Future secrecy also for group secret (in addition to pairwise channels)
    - Group key exchange: [KimPerTsu TISSEC ’04], [CCGMM ePrint ‘17]





Summary

- First security model for group instant messaging
  - Captures security and *reliability*
- Description (⇒ reverse engineering) of three major IM protocols
- Application of model to protocols
  - Revelation of discrepancies between security definition and protocols:

	Closeness	Forward Secrecy	Future Secrecy	Traceable Delivery	No Duplication	No Creation
💬	⚡		⚡	🗄		⚡
📞	🗄		✗	🗄		🗄
🔒	🗄	✗	✗	✗	🗄	🗄

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