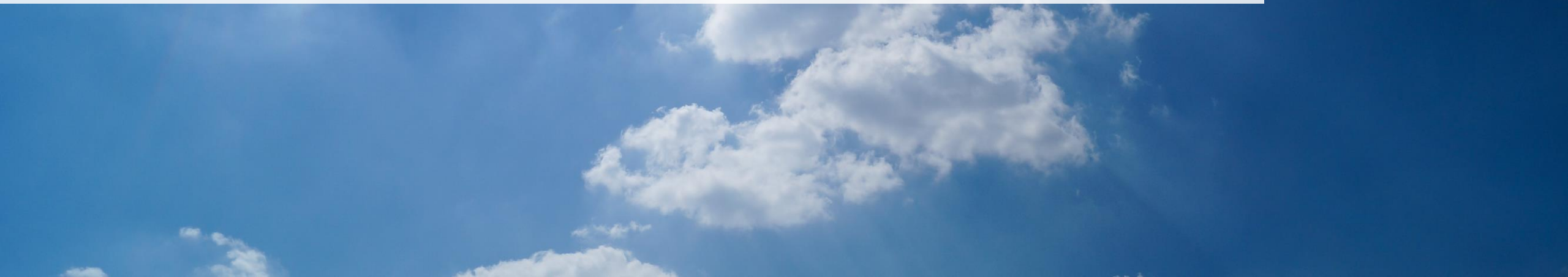
Taming Complexity of Messaging to understand its Security

ZISC Lunch Seminar

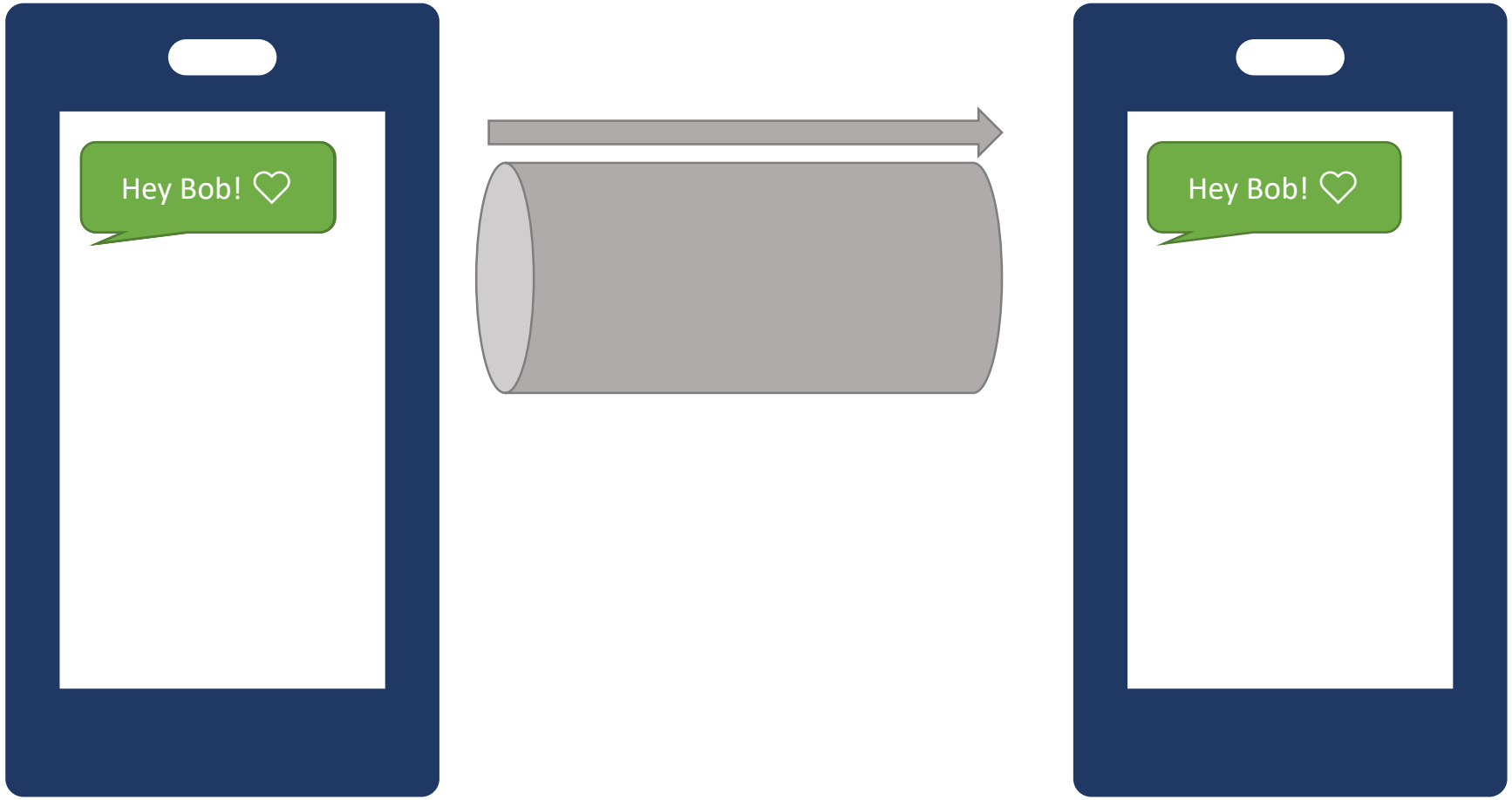
2019-10-10

Horst Görtz Institute for IT Security
Chair for Network and Data Security
Ruhr University Bochum
Paul Rösler



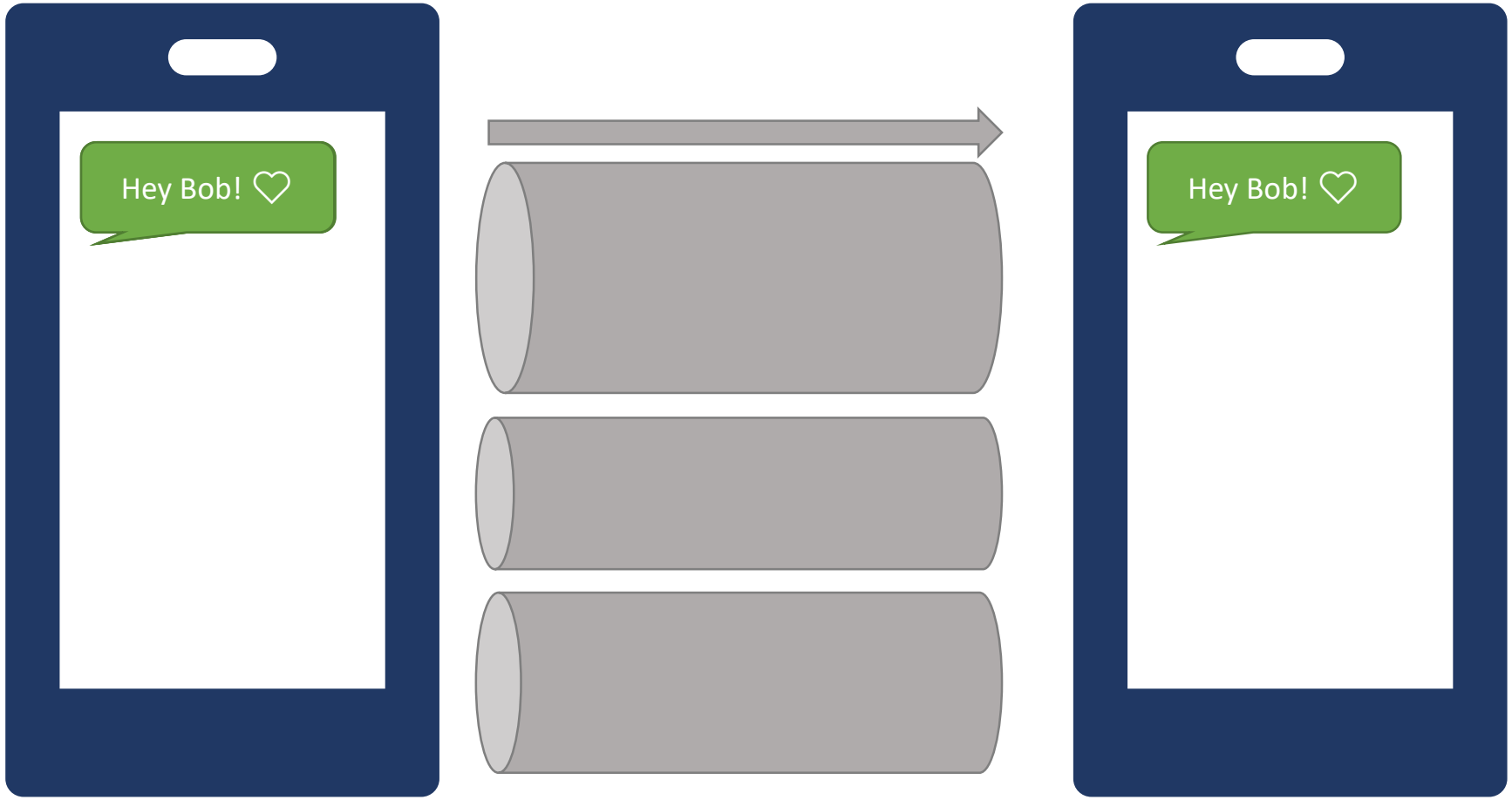
Messaging is complex

- (Asynchronous) session initialization
- “Secure” channel



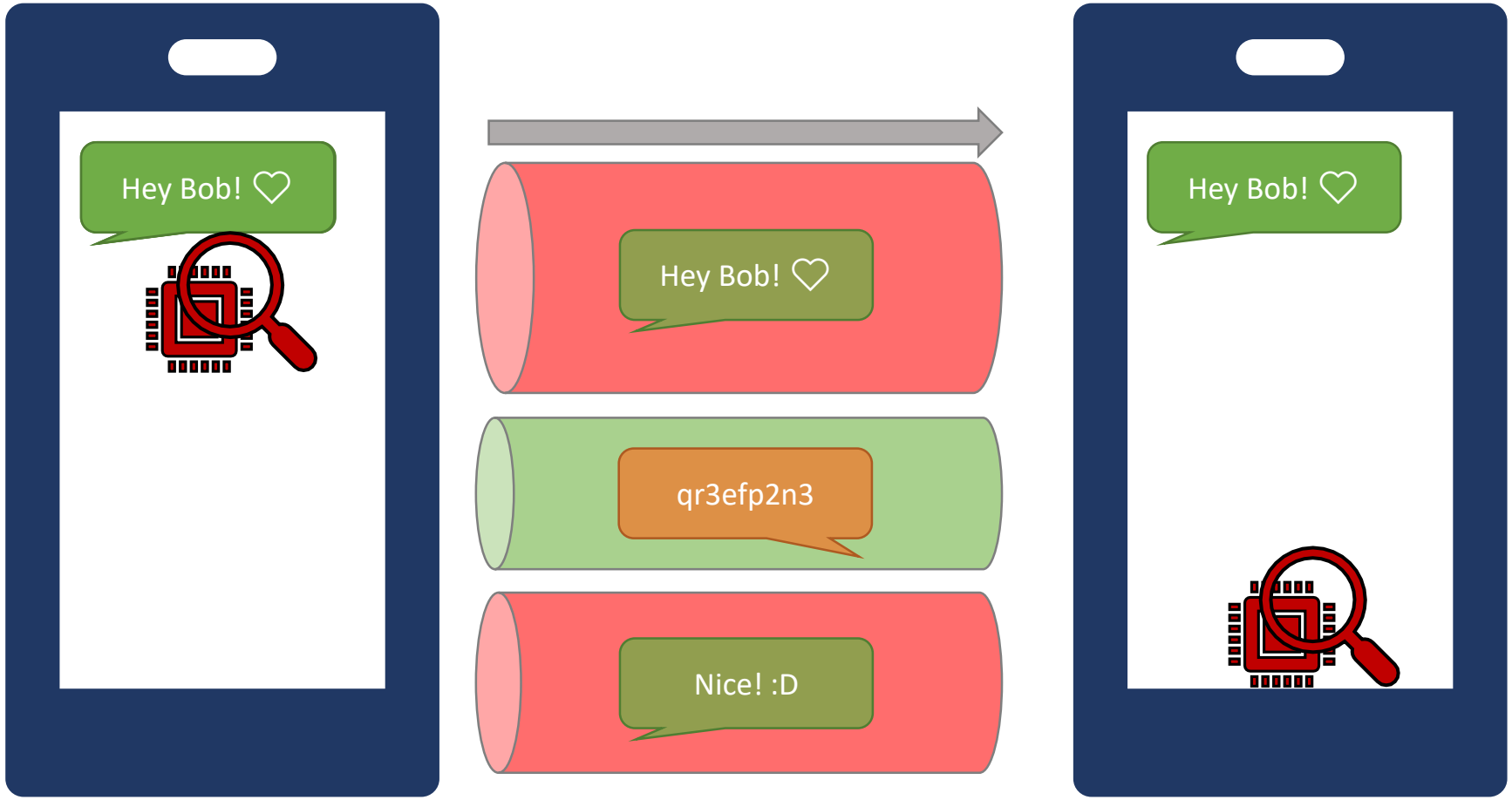
Messaging is complex

- (Asynchronous) session initialization
- “Secure” channel
- Strong security



Messaging is complex

- (Asynchronous) session initialization
- “Secure” channel
- Strong security

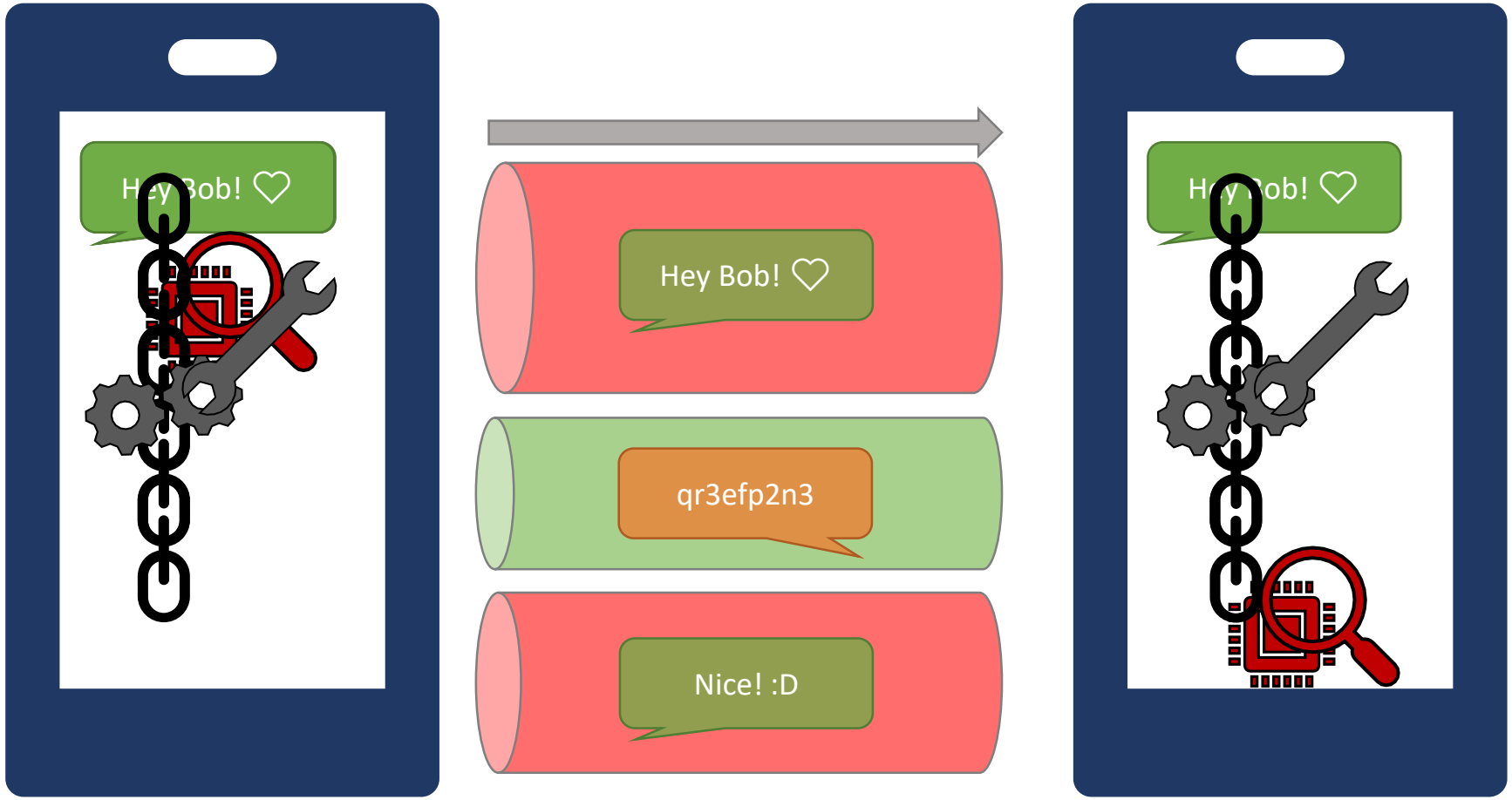


Messaging is complex

- (Asynchronous) session initialization
- “Secure” channel
- Strong security

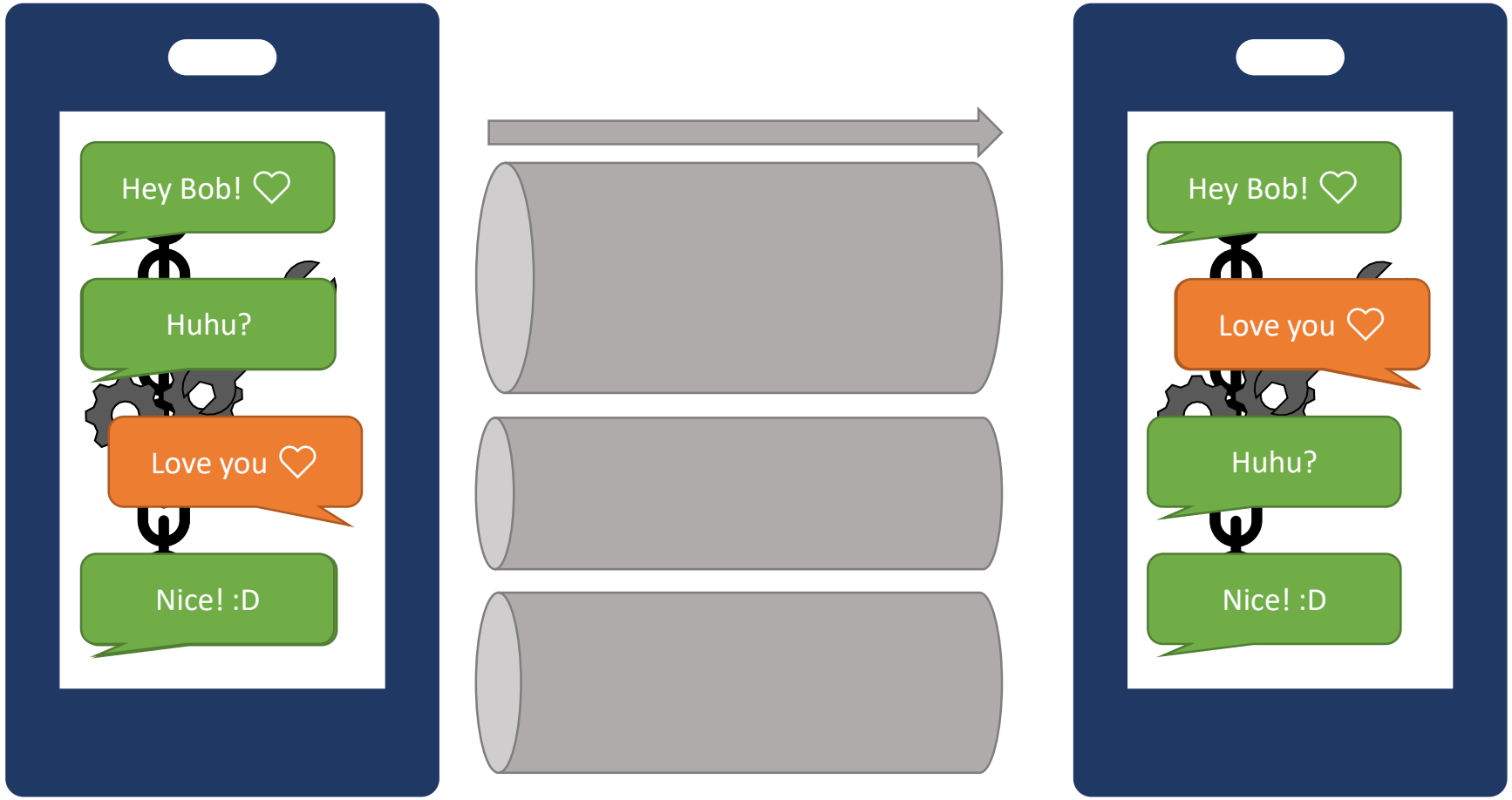
  “Ratchet”-Mechanism:
  - Invalidate old secrets
  - Sample and include new secrets
  - Origin:

  Simple construction:
  - Repetition and mix of key exchanges



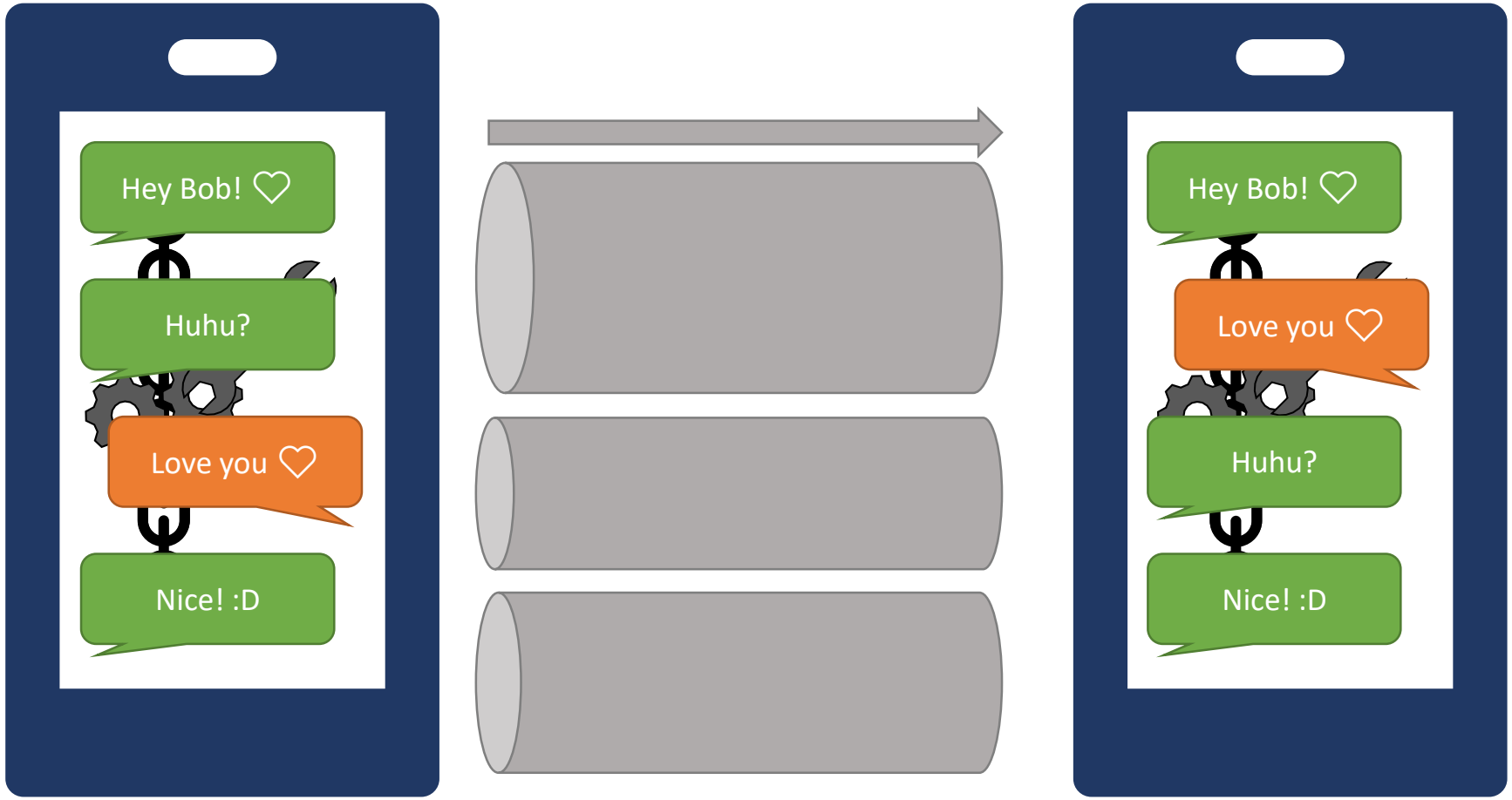
Messaging is complex

- (Asynchronous) session initialization
- “Secure” channel
- Strong security
- Concurrent communication



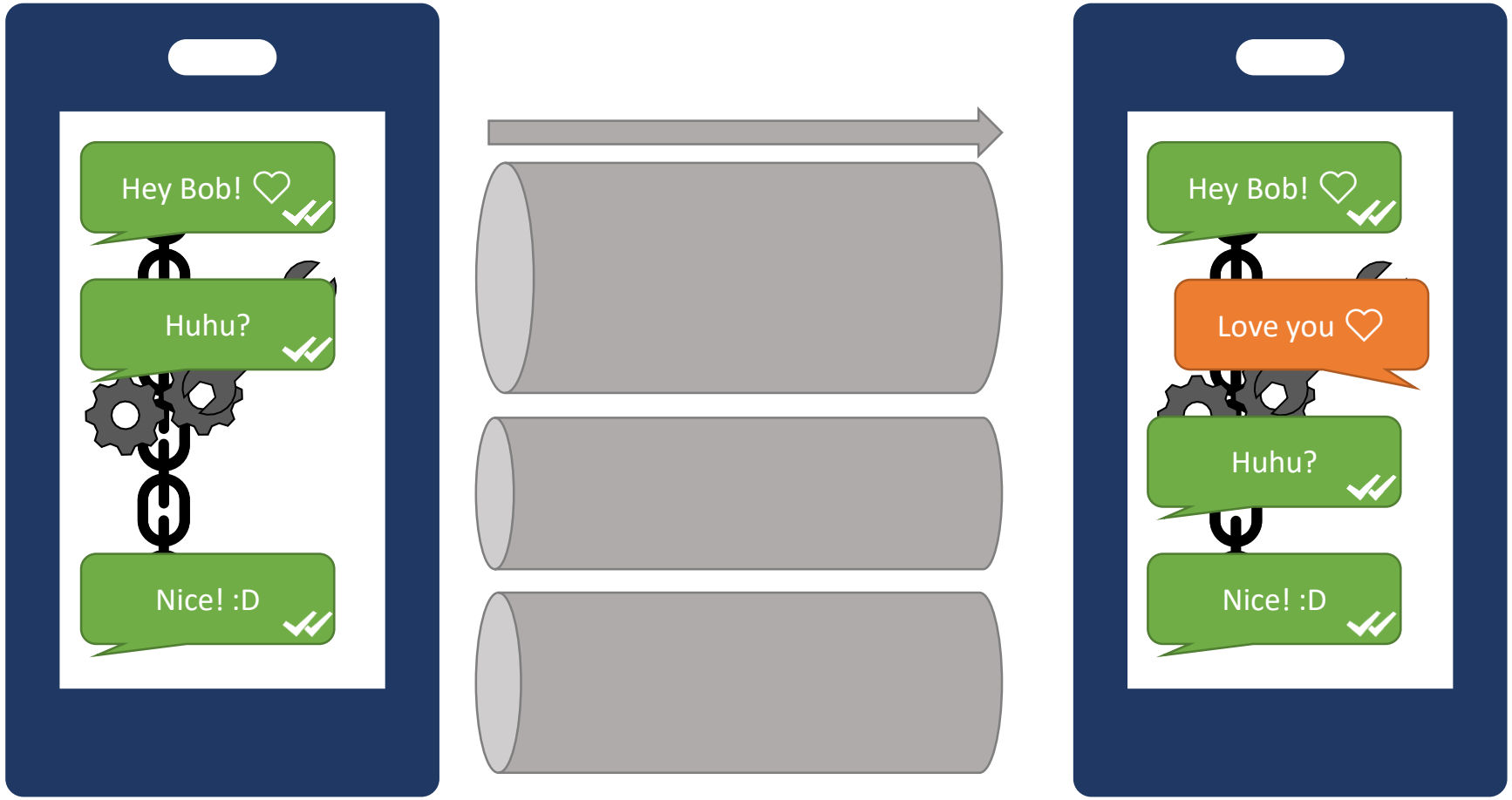
Messaging is complex

- (Asynchronous) session initialization
- “Secure” channel
- Strong security
- Concurrent communication
- Unreliable network



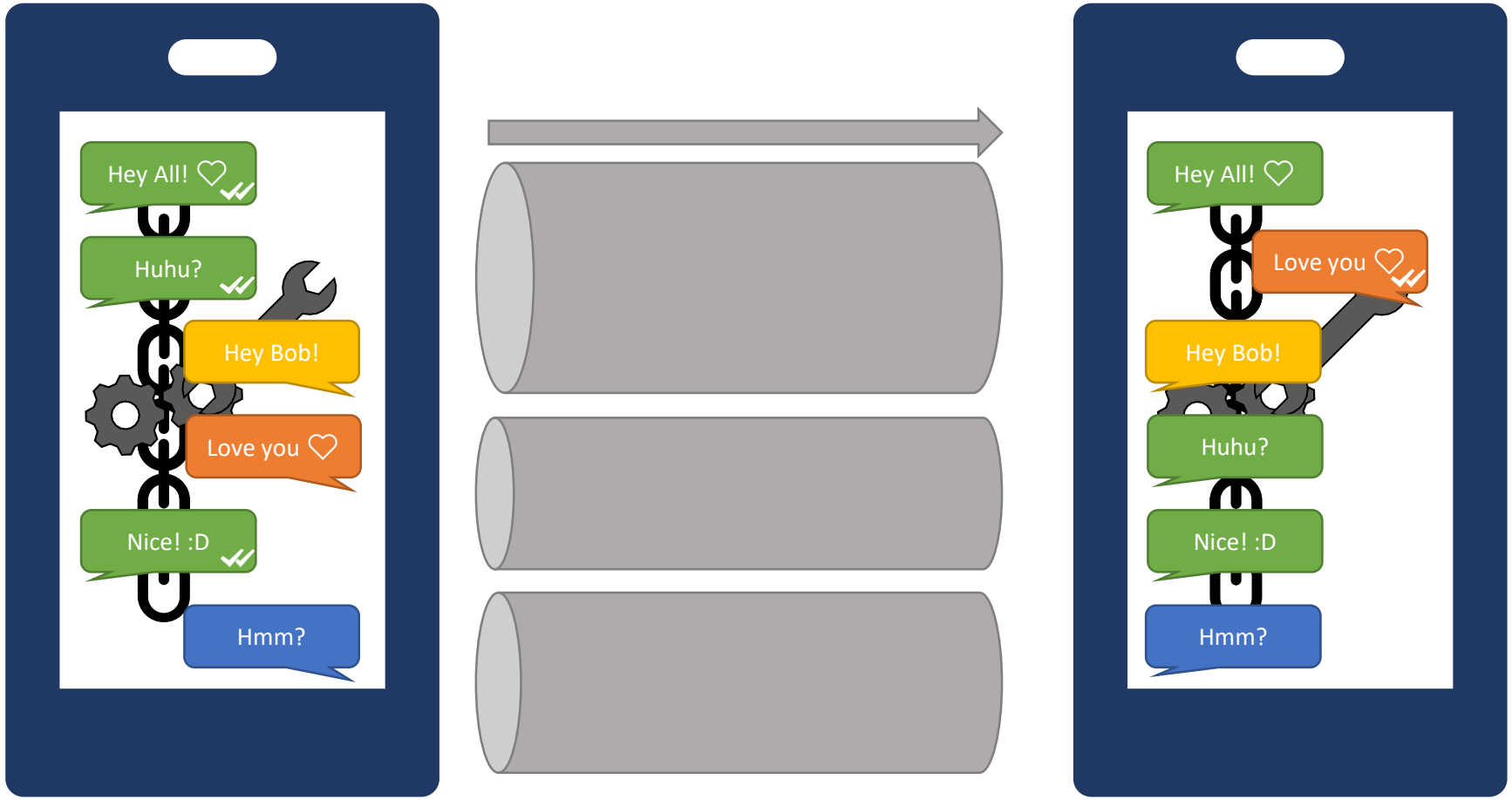
Messaging is complex

- (Asynchronous) session initialization
- “Secure” channel
- Strong security
- Concurrent communication
- Unreliable network
- Explicit reliability



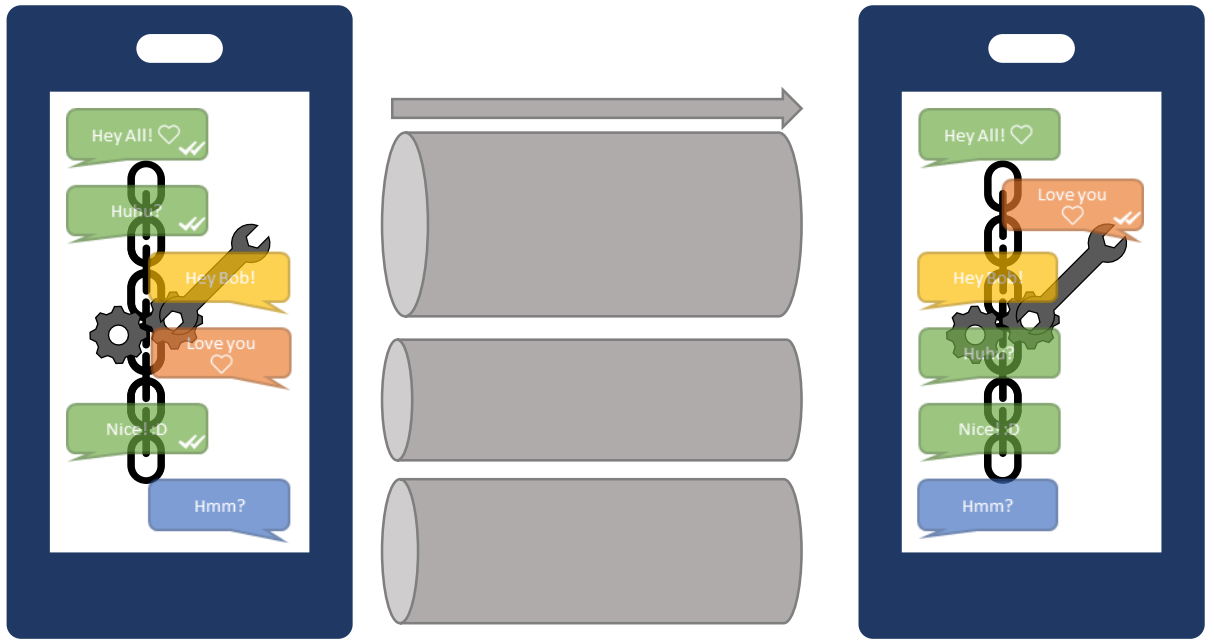
Messaging is complex

- (Asynchronous) session initialization
- “Secure” channel
- Strong security
- Concurrent communication
- Unreliable network
- Explicit reliability
- Group communication



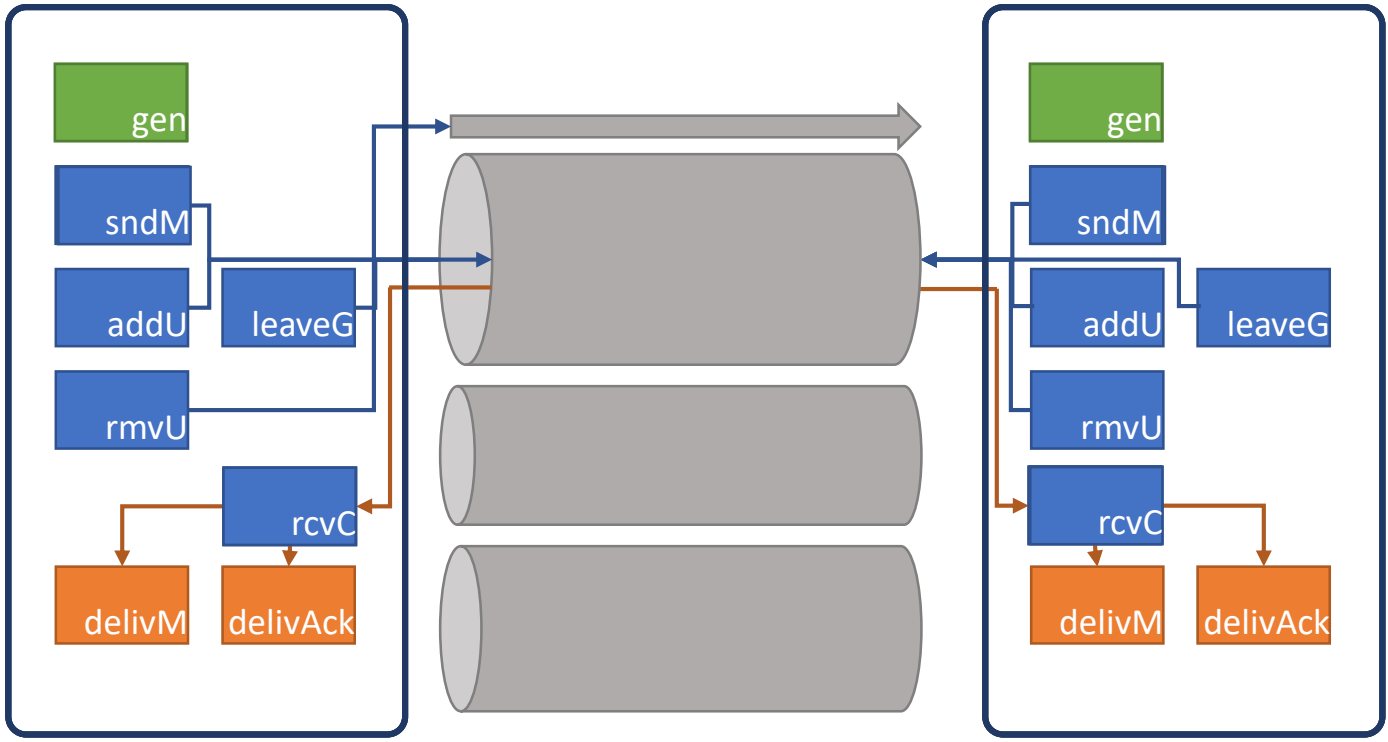
Agenda

- Messaging is complex
- **Finding a Syntax**
- Understanding Attackers
- Defining Security
- Understanding Constructions



Syntax – Taming complexity

- Messenger with
  - Many user interfaces
    - Dynamic groups
    - Explicit reliability
  - Complex functionality
  - Nearly impossible to define security formally
  - Was used to motivate attacks



More is Less: On the End-to-End Security of Group Chats in Signal, WhatsApp, and Threema

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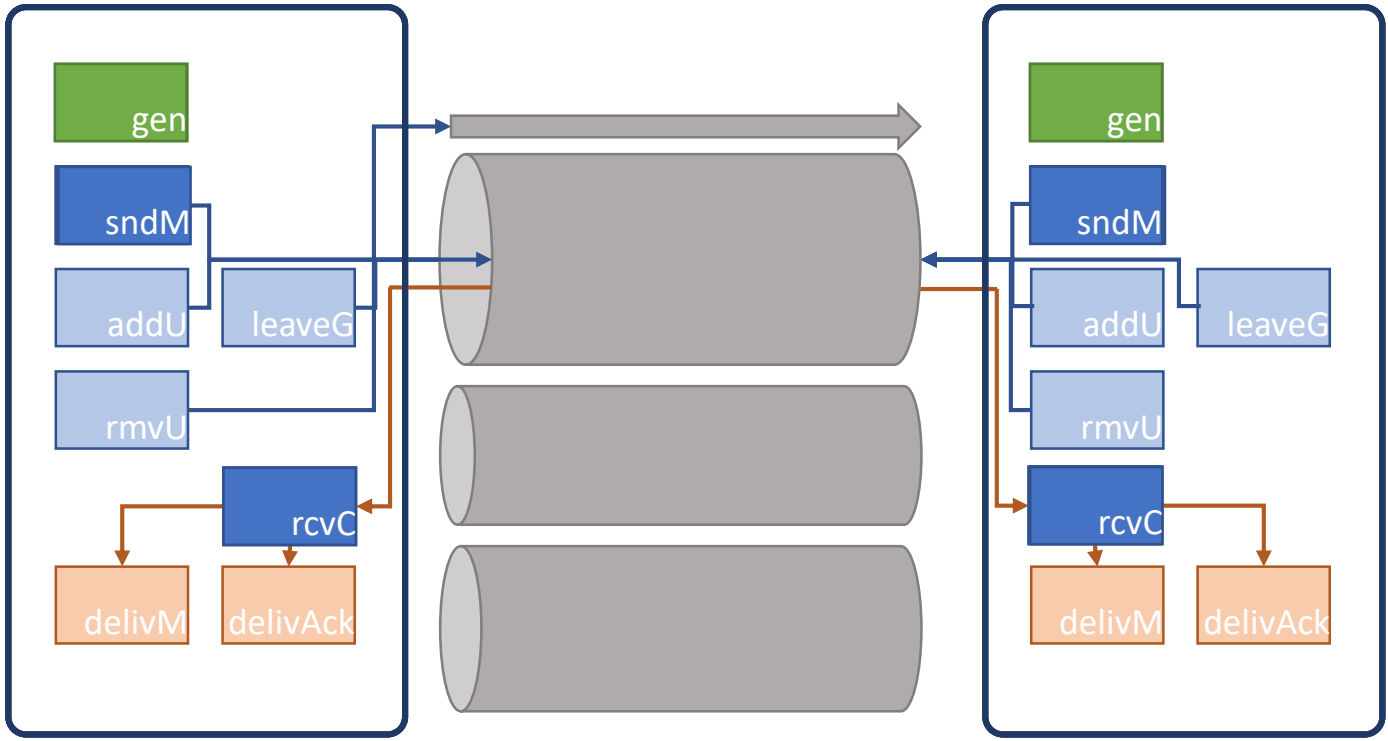
Chair for Network and Data Security
Ruhr-University Bochum

Messenger

Syntax – Taming complexity

- Remove:
  1. Delivery notifications
  2. Group channels
  3. Group management



Messenger

Syntax – Taming complexity

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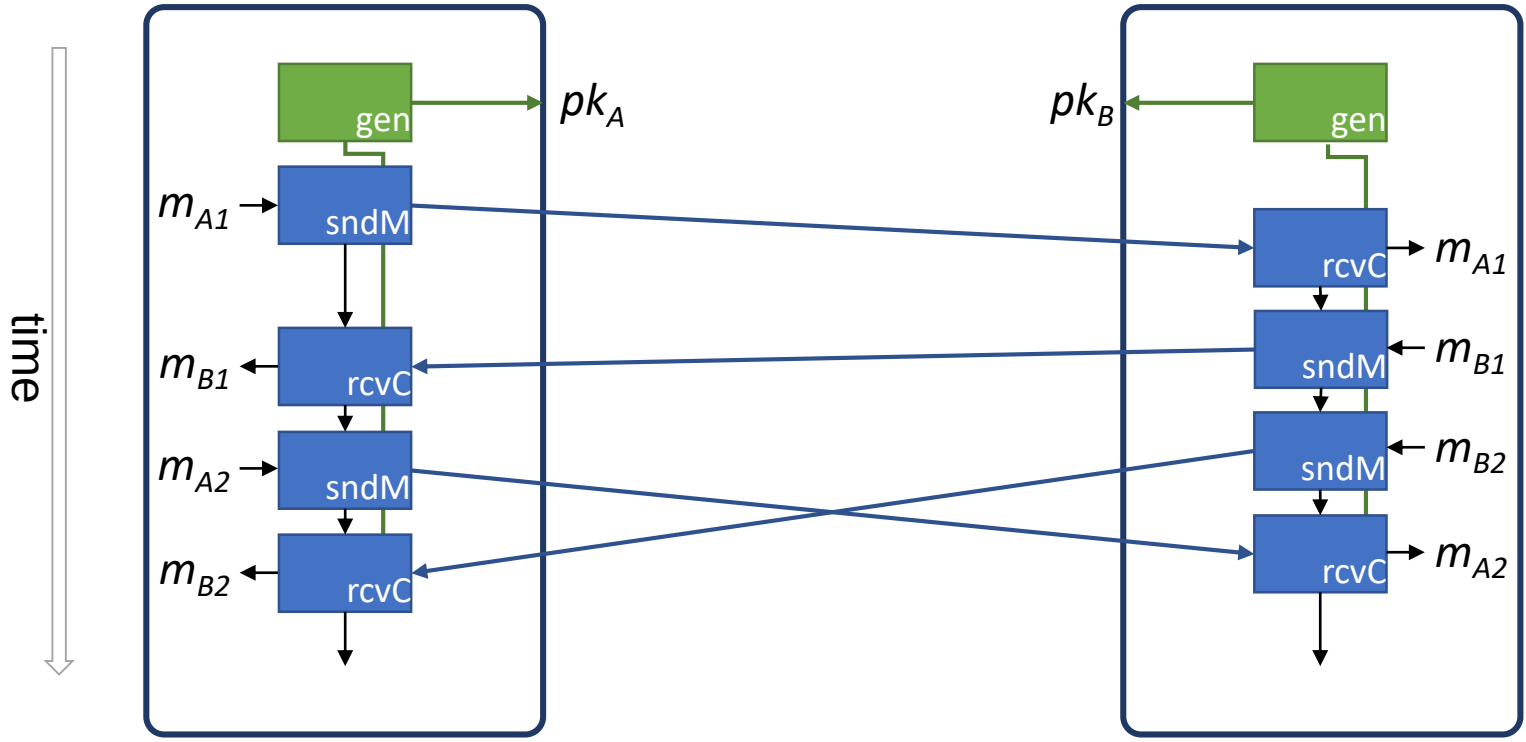


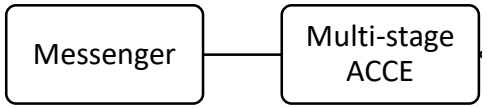
Messenger

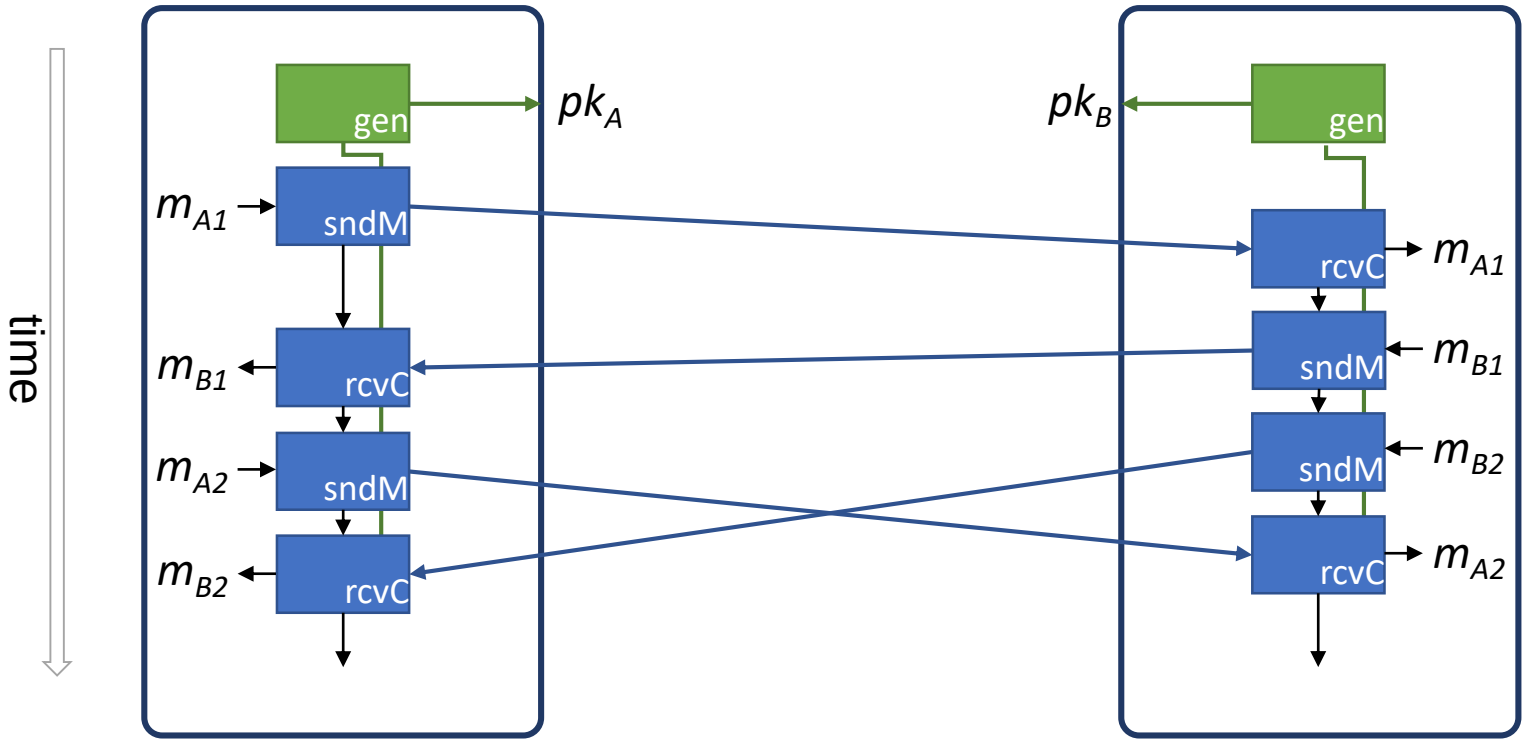
Syntax – Taming complexity

- Remove:
  1. Delivery notifications
  2. Group channels
  3. Group management

  - Still very complex
  - Multiple parties & sessions
  - Establishment & channel

Two party channel (including establishment)





Flexible Authenticated and Confidential Channel Establishment (fACCE): Analyzing the Noise Protocol Framework

Benjamin Dowling[1], Paul Rösler[2], and Jörg Schwenk[2]

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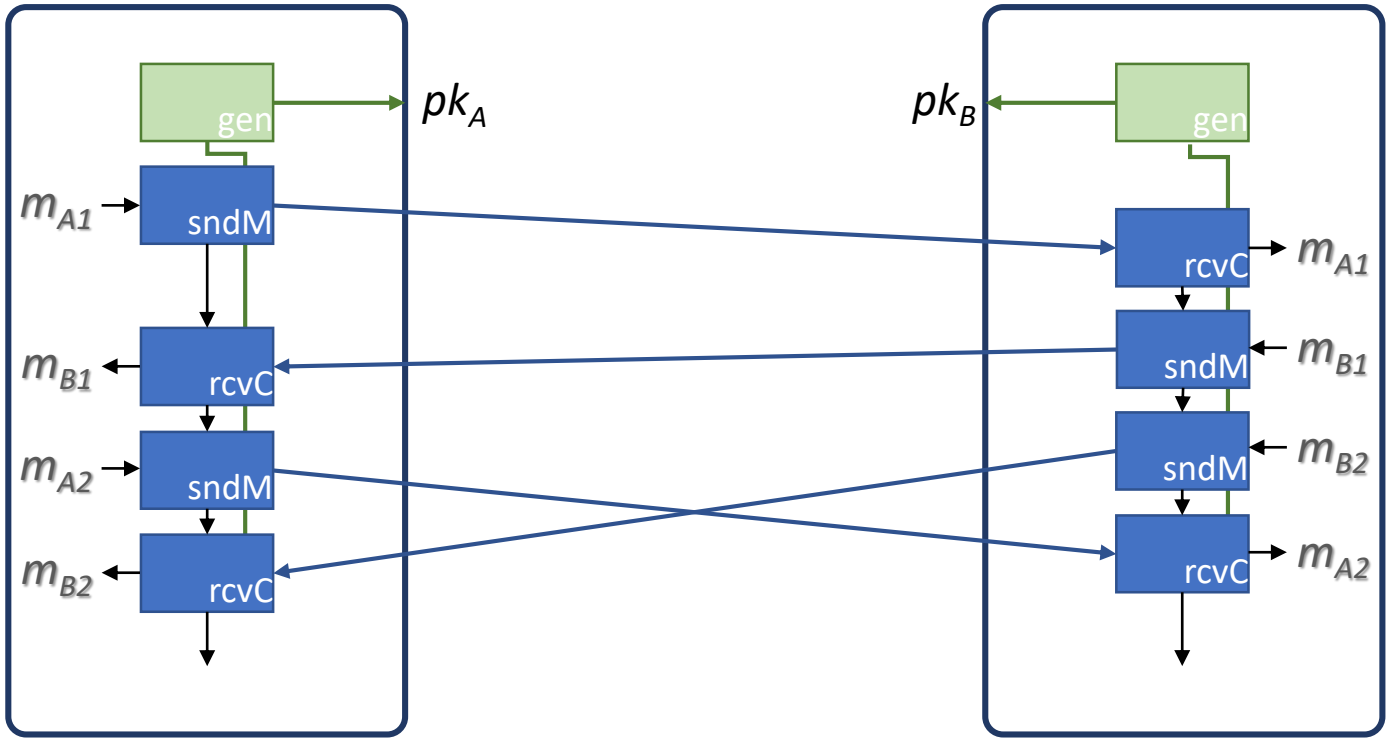
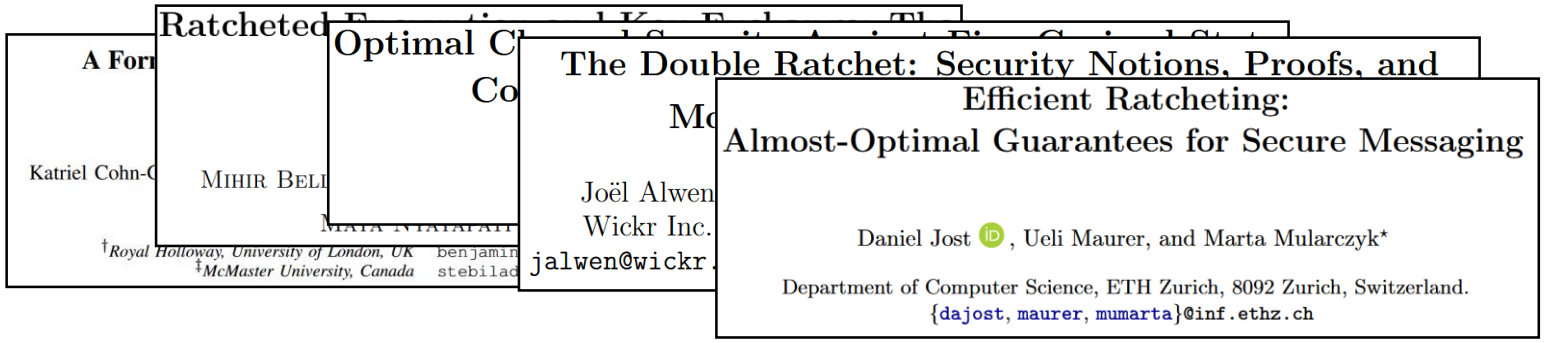
{paul.roesler,joerg.schwenk}@rub.de

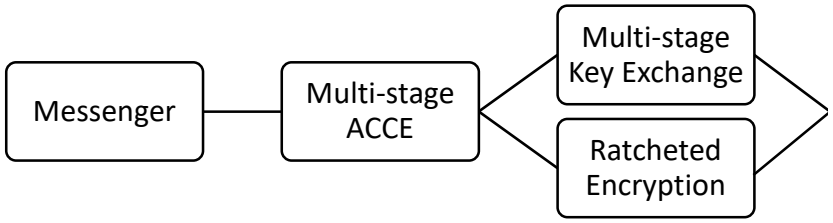
Syntax – Taming complexity

- Remove:
  1. Delivery notifications
  2. Group channels
  3. Group management
  4. Channel establishment
  5. Symmetric encryption

  - Some publications removed (only) one of both:



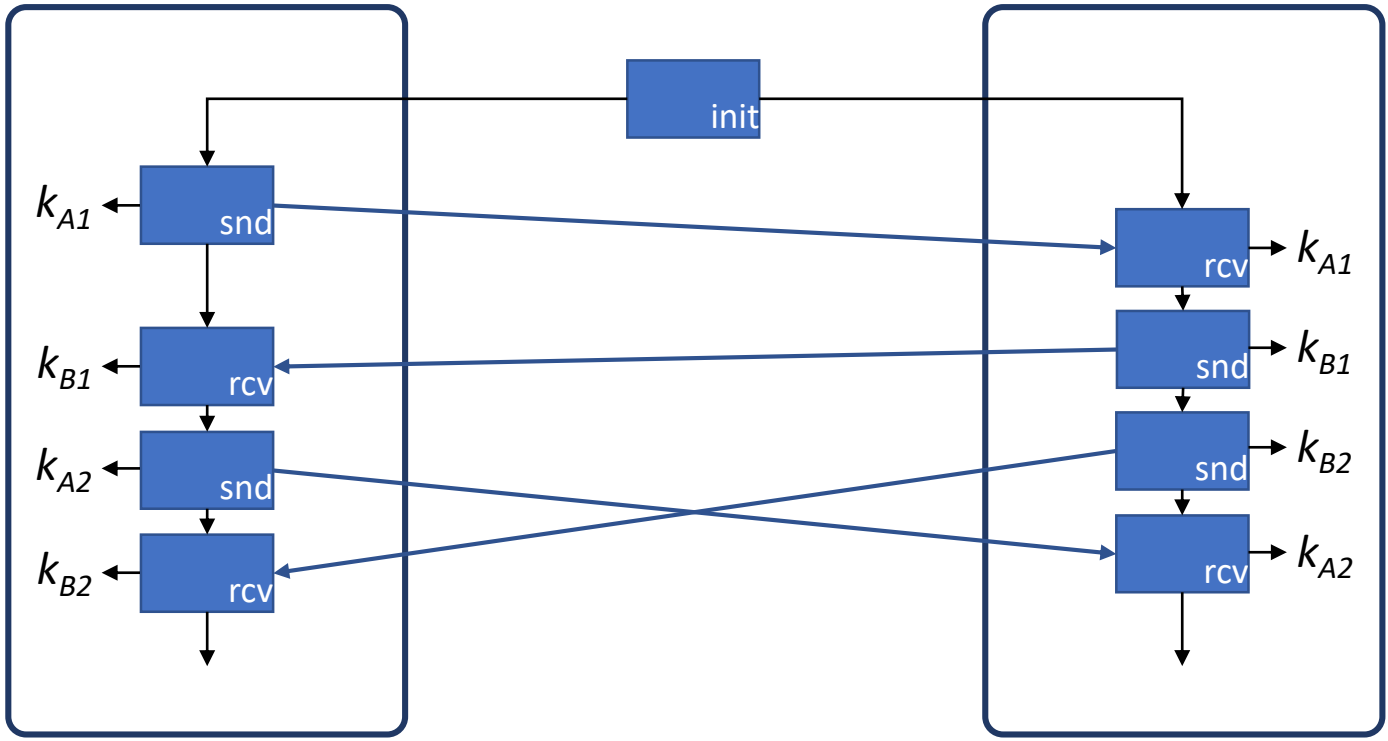




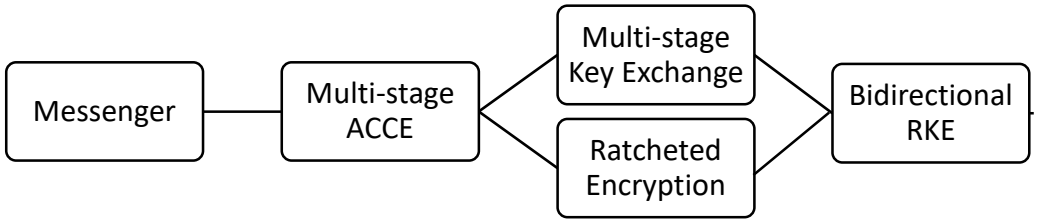
Syntax – Taming complexity

- Remove:
  1. Delivery notifications
  2. Group channels
  3. Group management
  4. Channel establishment
  5. Symmetric encryption

  - Still (*too*) complex to define (and understand) strong security



Ratcheted key exchange



Asynchronous ratcheted key exchange

Bertram Poettering[1] and Paul Rösler[2]

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bertram.poettering@rhul.ac.uk
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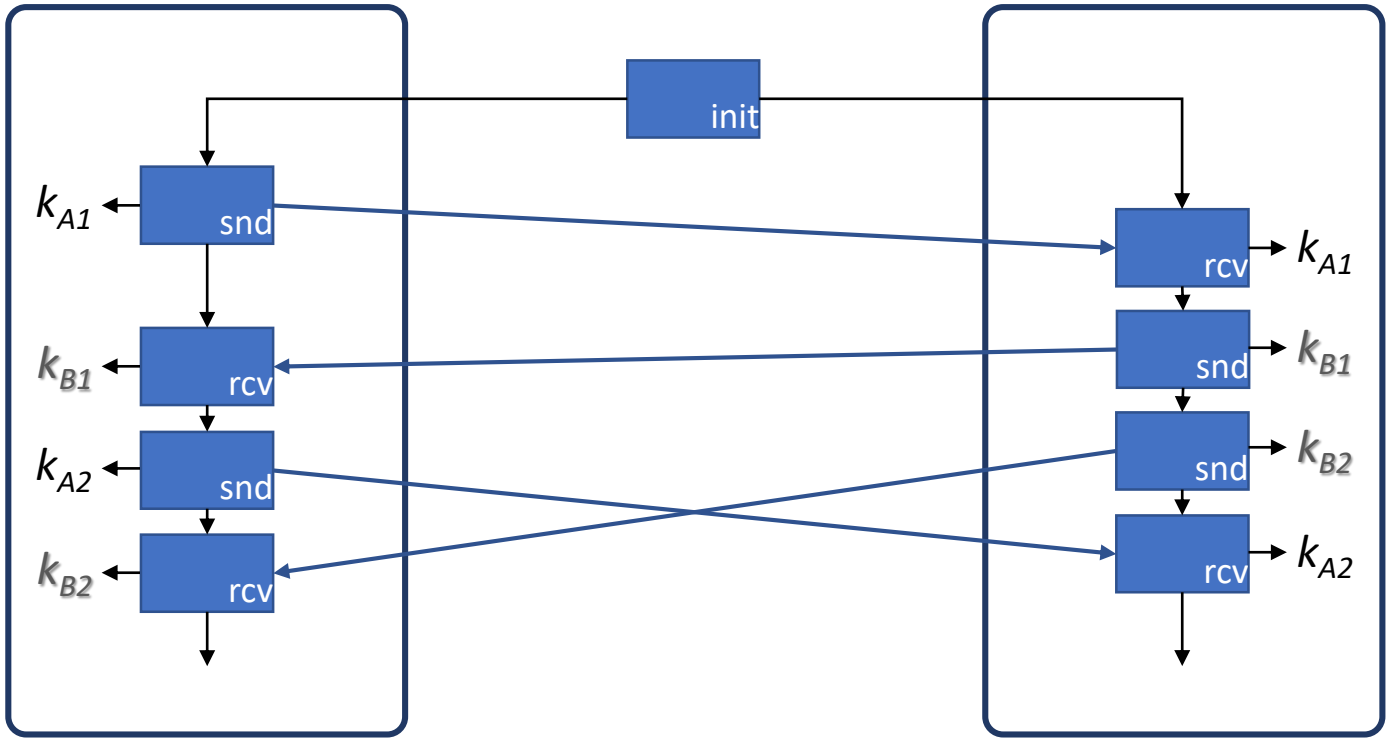
Chair for Network and Data Security, Ruhr-University Bochum
paul.roesler@rub.de

Syntax – Taming complexity

- Remove:
  1. Delivery notifications
  2. Group channels
  3. Group management
  4. Channel establishment
  5. Symmetric encryption
  6. Key establishment B-to-A



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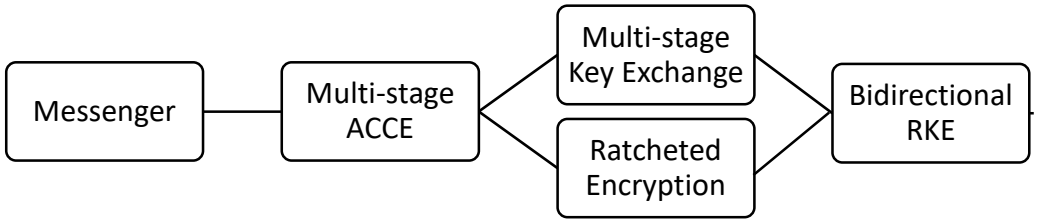

Syntax – Taming complexity

- Remove:
  1. Delivery notifications
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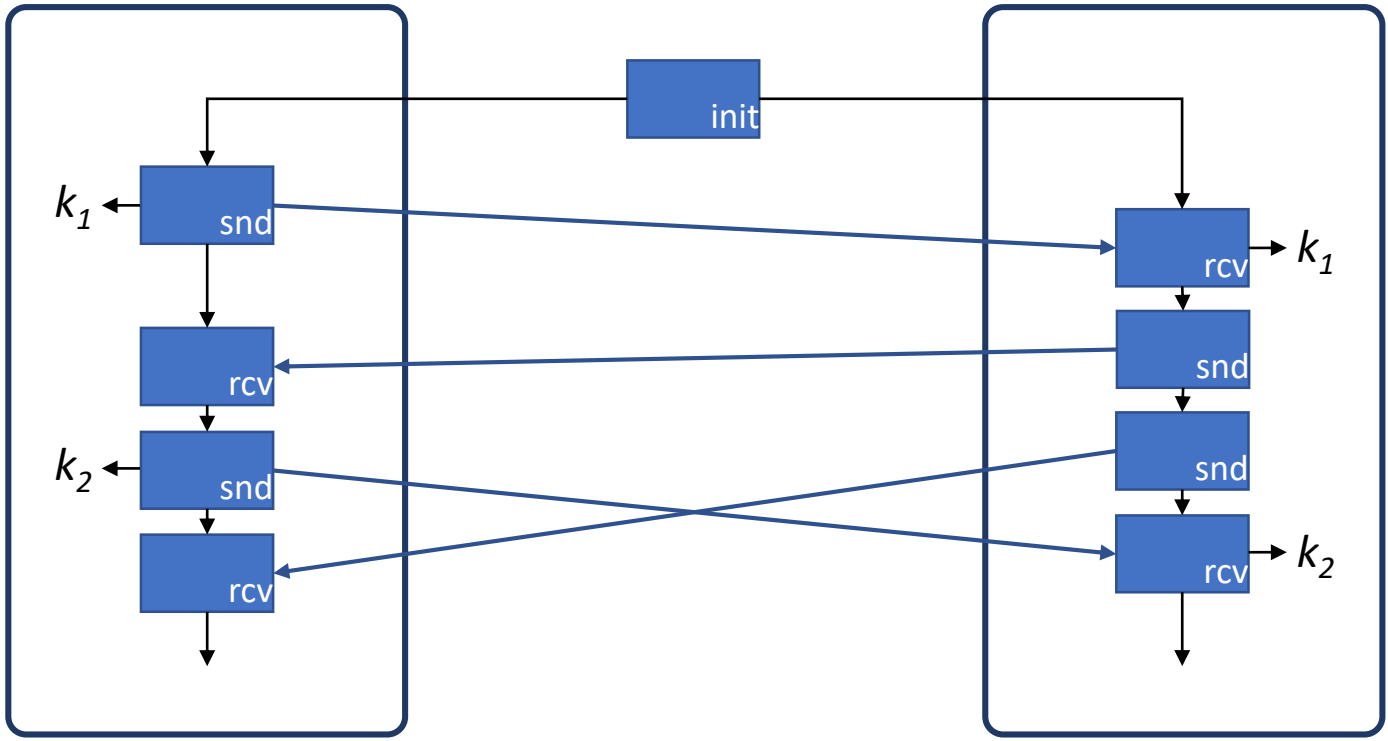
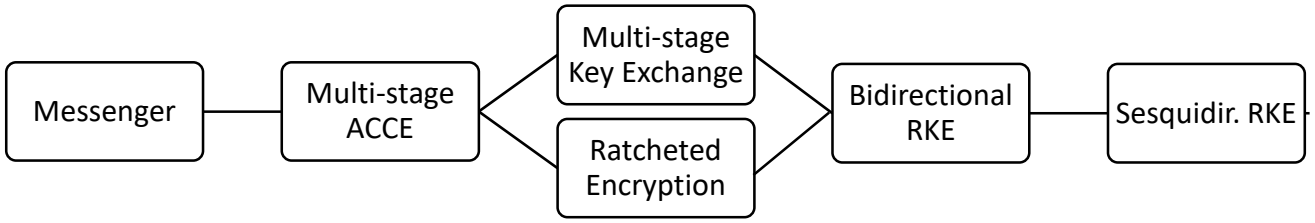
  4. Channel establishment
  5. Symmetric encryption
  6. Key establishment B-to-A

  - It can even be simpler ☺





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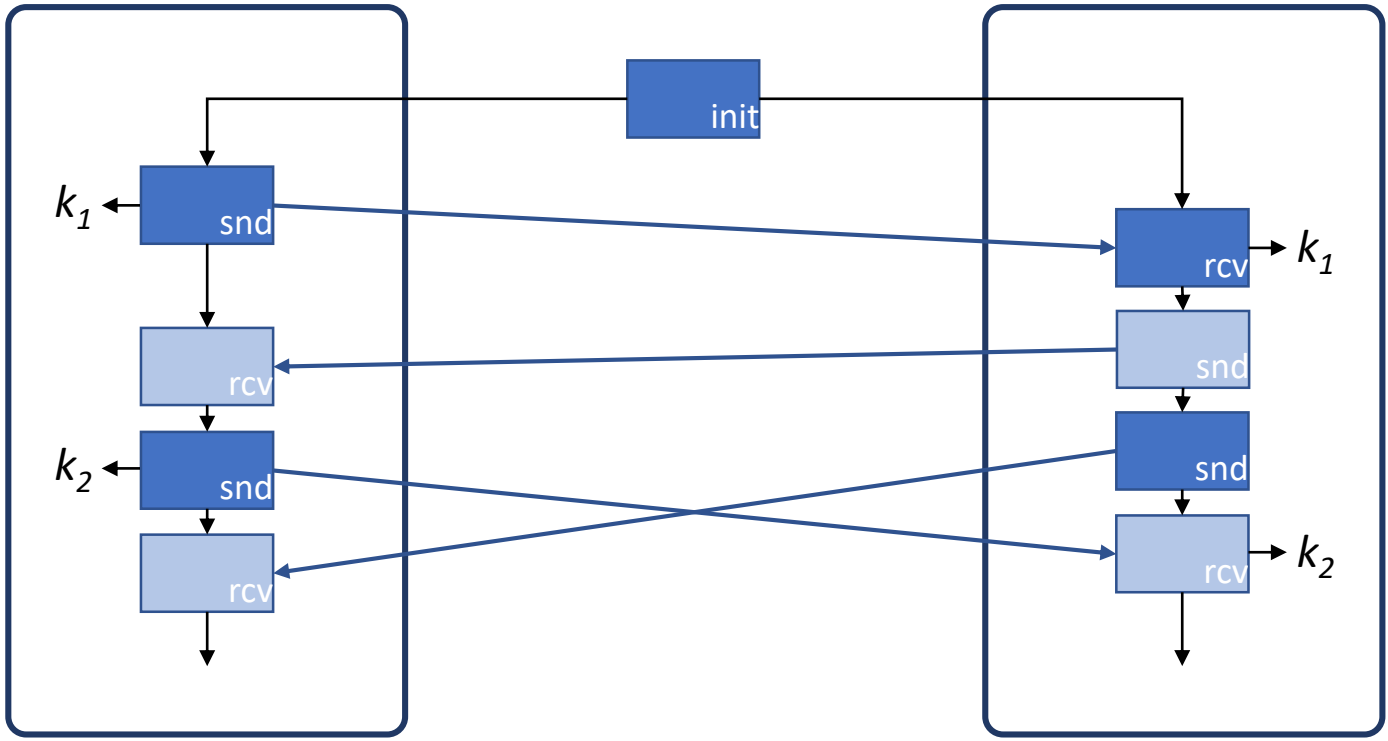
Syntax – Taming complexity

- Remove:
  1. Delivery notifications
  2. Group channels
  3. Group management
  4. Channel establishment
  5. Symmetric encryption
  6. Key establishment B-to-A
  7. B-to-A communication
  - It can even be simpler ☺



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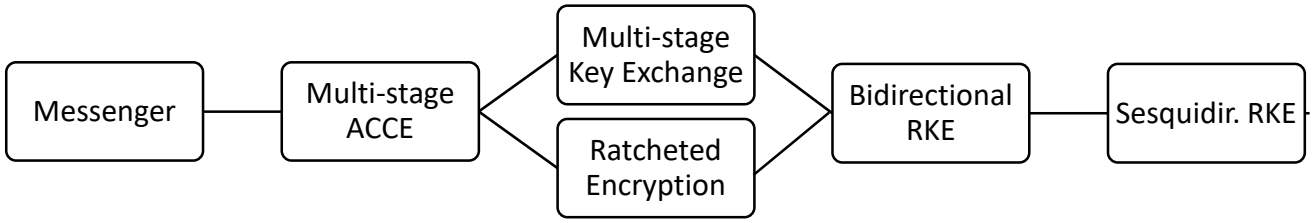

Syntax – Taming complexity

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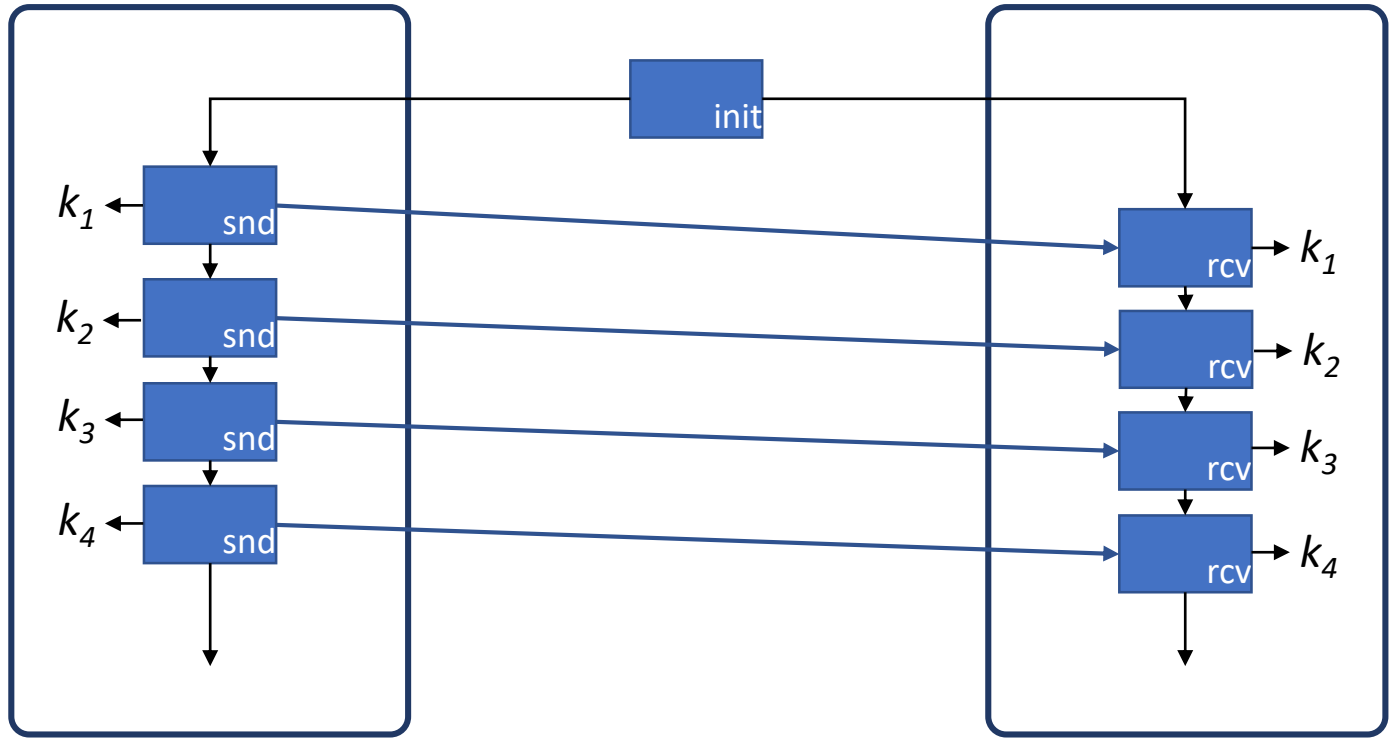
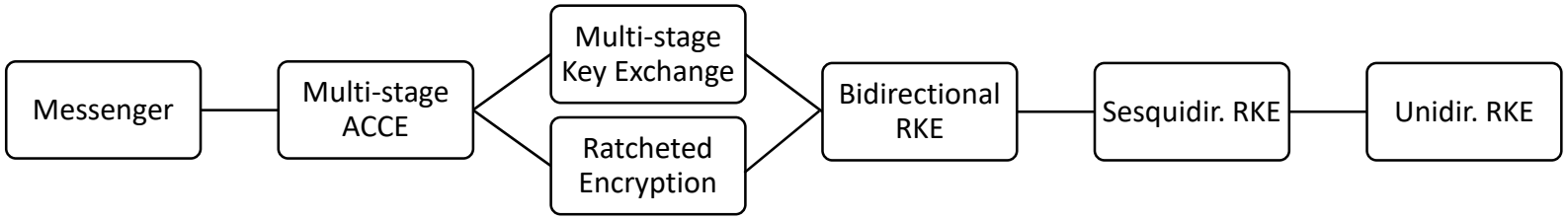
  4. Channel establishment
  5. Symmetric encryption
  6. Key establishment B-to-A
  7. B-to-A communication



Unidirectional ratcheted key exchange



Asynchronous ratcheted key exchange

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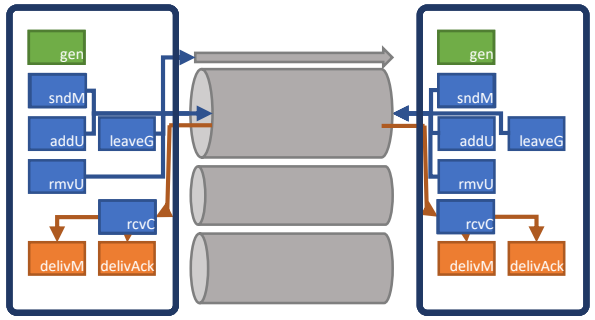
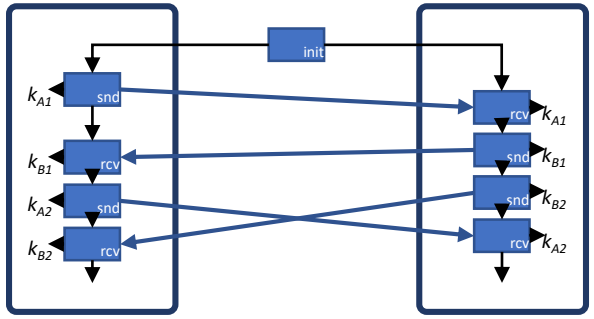
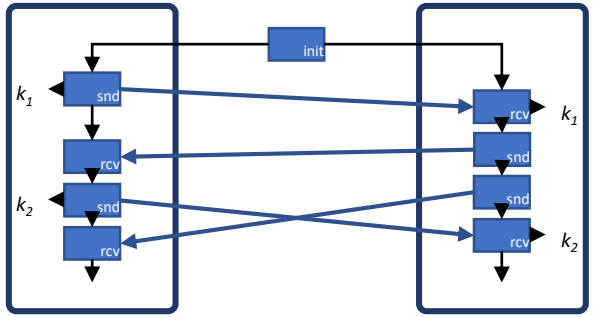
Syntax – Taming complexity



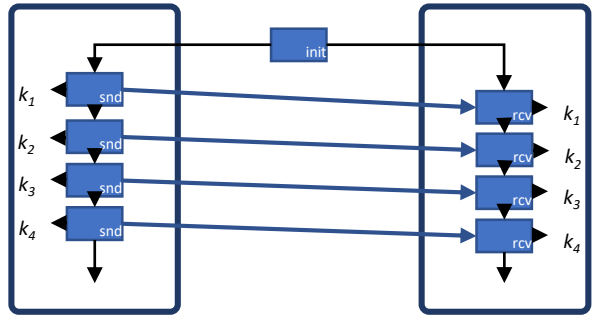


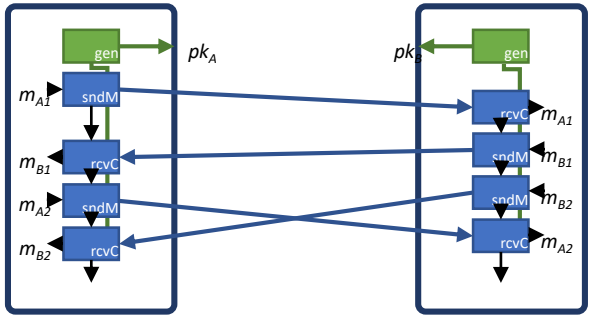
- Abstract initialization
- No symmetric encryption

- No B-to-A key establishment

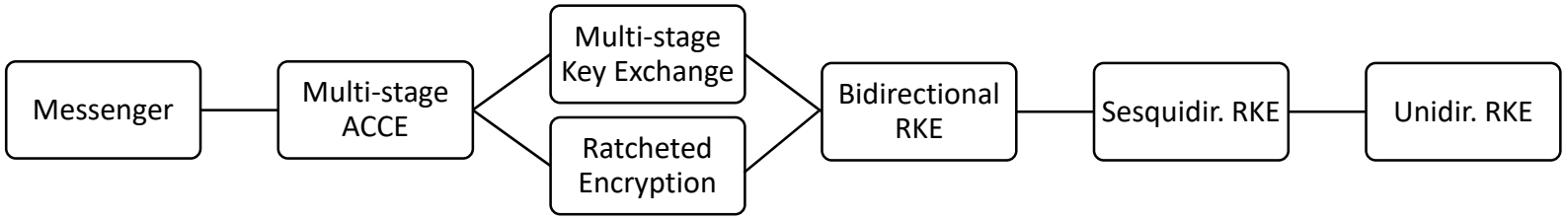


- No B-to-A communication

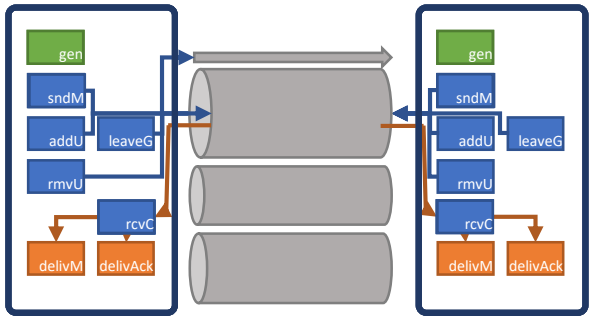


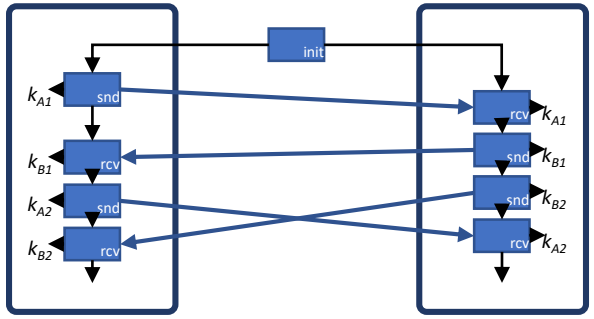


- No groups
- Only pair-wise communication



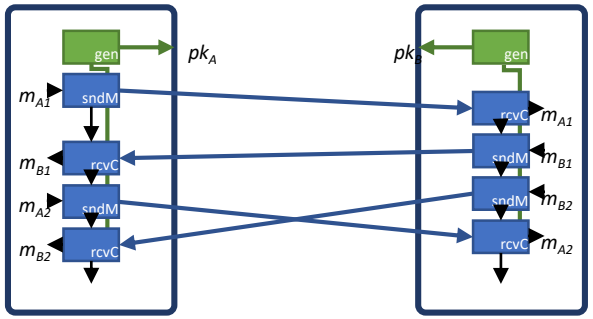
Syntax – Modularity

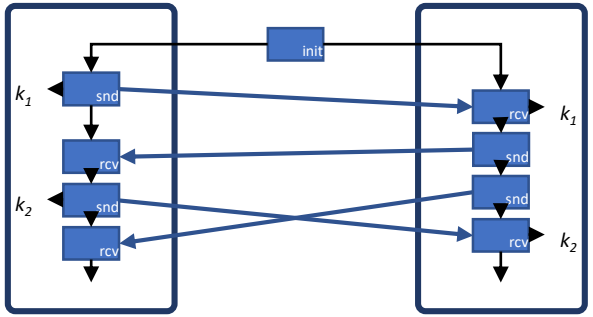




- Copy and merge

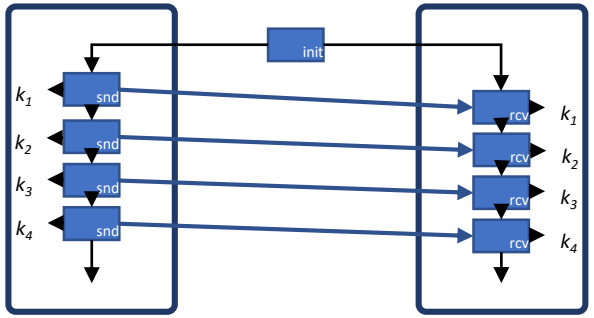
- Initialize with key exchange
- Add authenticated encryption

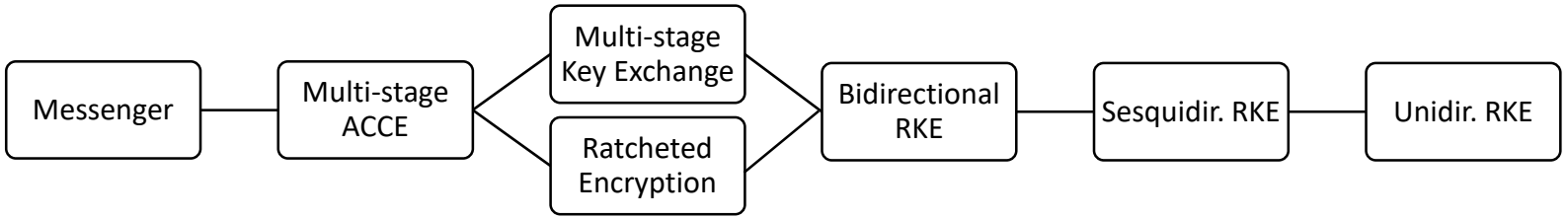




- ???
  We will see…

- N pair-wise channels
- Send acks





Agenda

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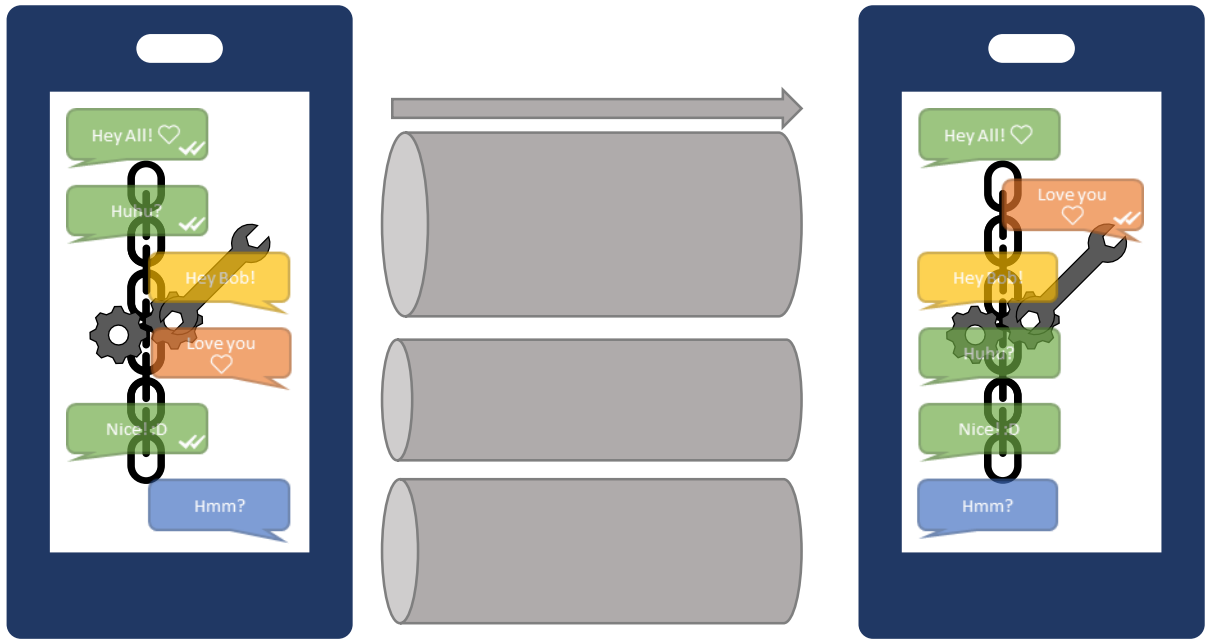
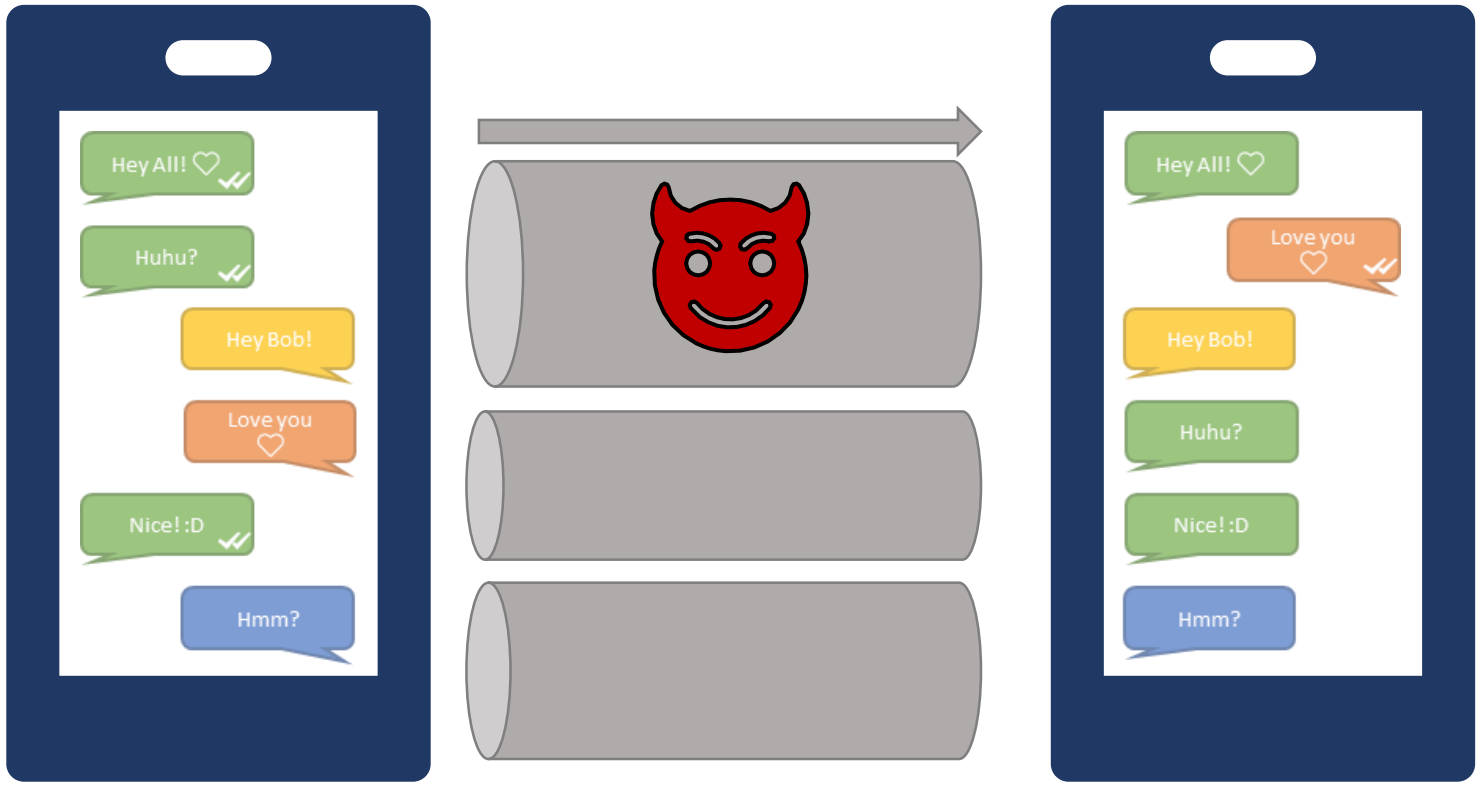
- **Understanding Attackers**
- Defining Security
- Understanding Constructions



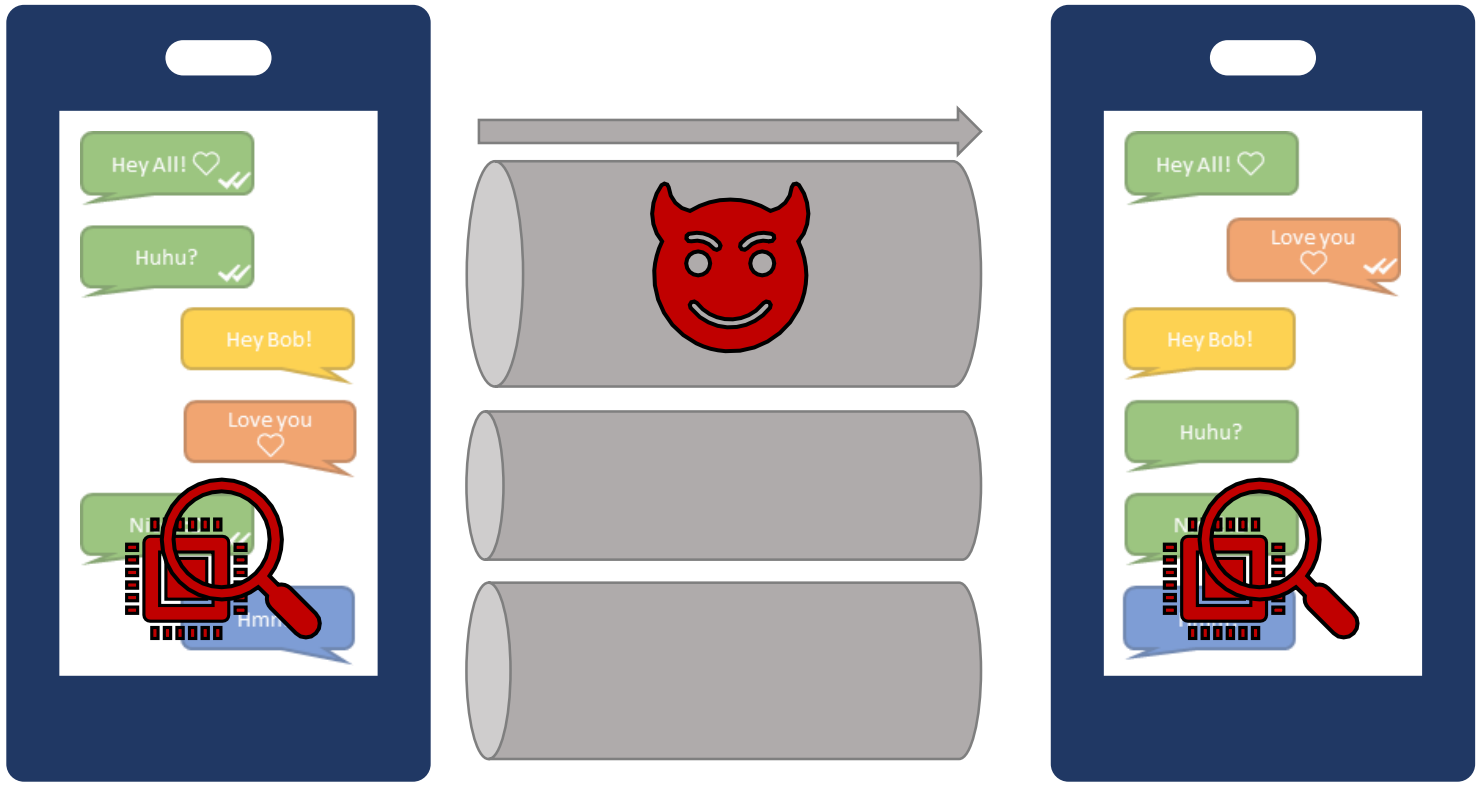
Attacker

- Active attacker on network



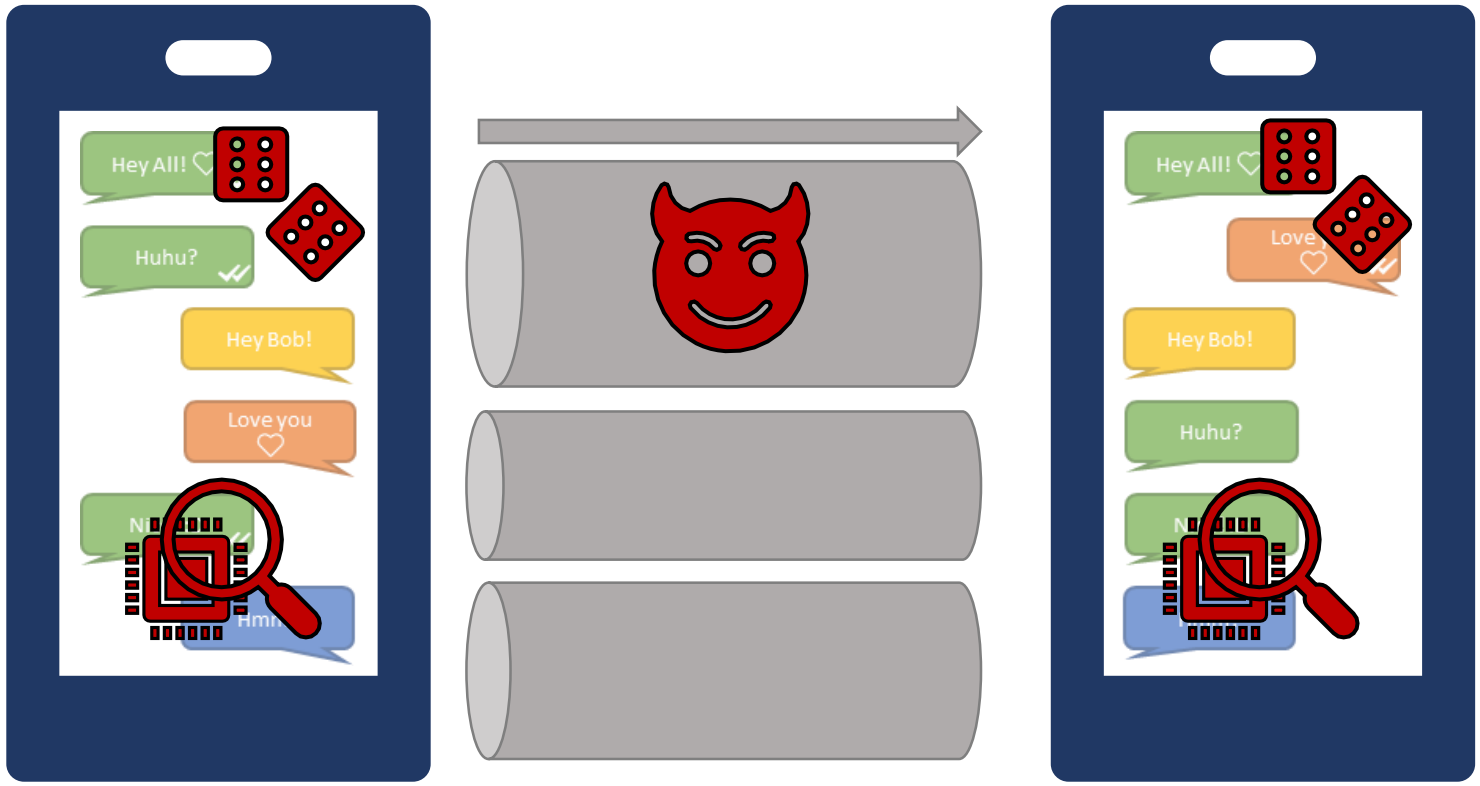
Attacker

- Active attacker on network
- Exposure of secret states
  - Mobile devices are easily accessible
  - Sessions take long time



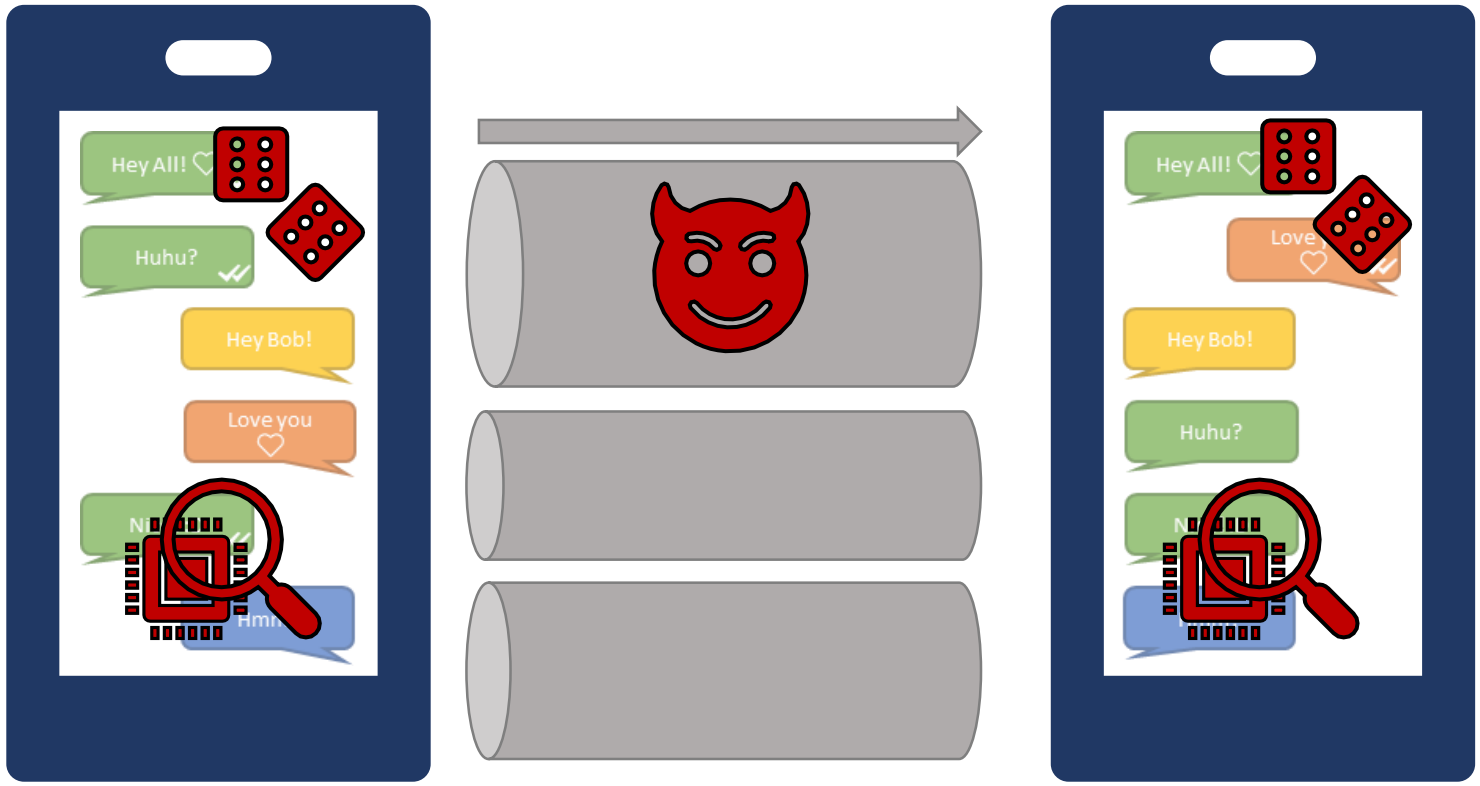
Attacker

- Active attacker on network
- Exposure of secret states
- Attacks against executions' randomness
  - Entropy low
  - Ba(d/ckdoored) randomness generator



Attacker

- Many more attacker scenarios…
  - Attacker against key distribution
  - Attackers in attacked group
  - Leakage during computation
  - Attacker in implementation



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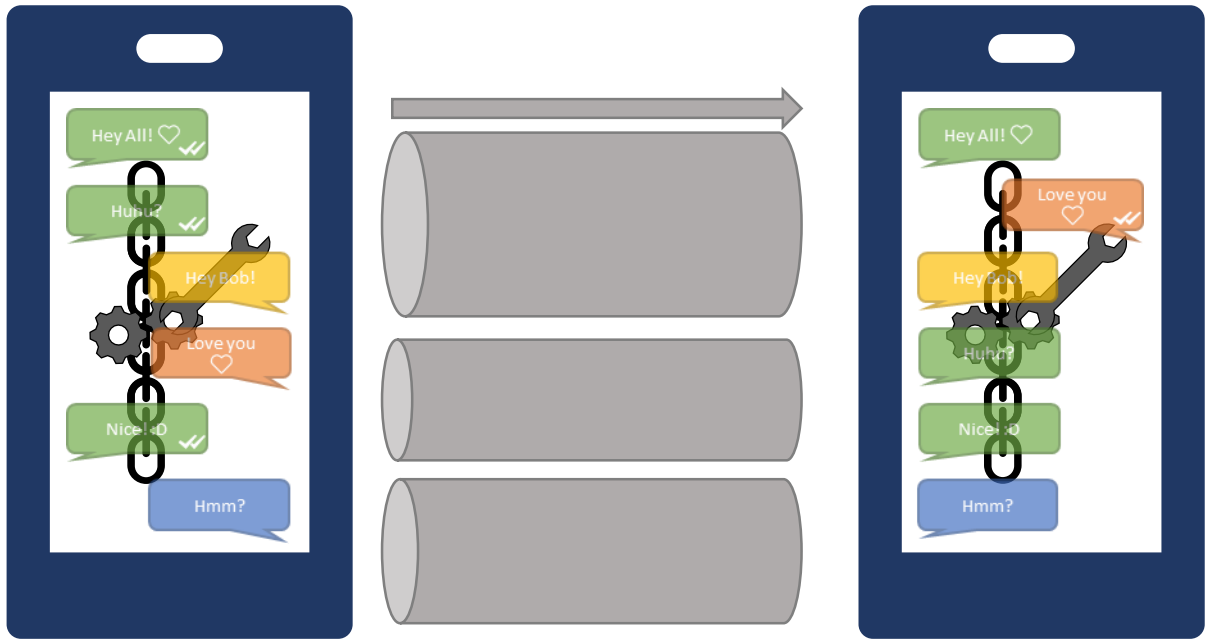
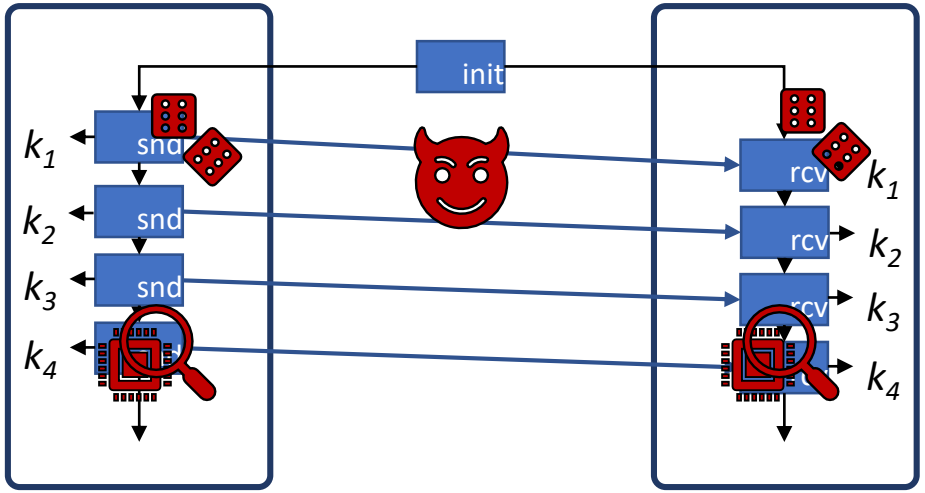
- **Defining Security**
- Understanding Constructions



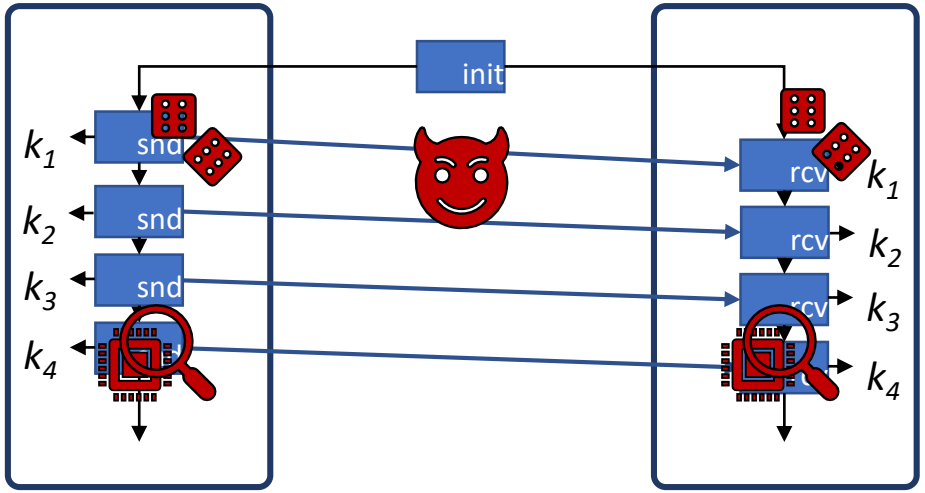
Security definition

- Many security properties, depend on:
  - Syntax
  - Correctness
  - Semantic
- Multiple levels of properties:
  - **Strongest security**
  - Intuitive security (ambiguous)
  - Efficiently instantiable security (ambiguous)



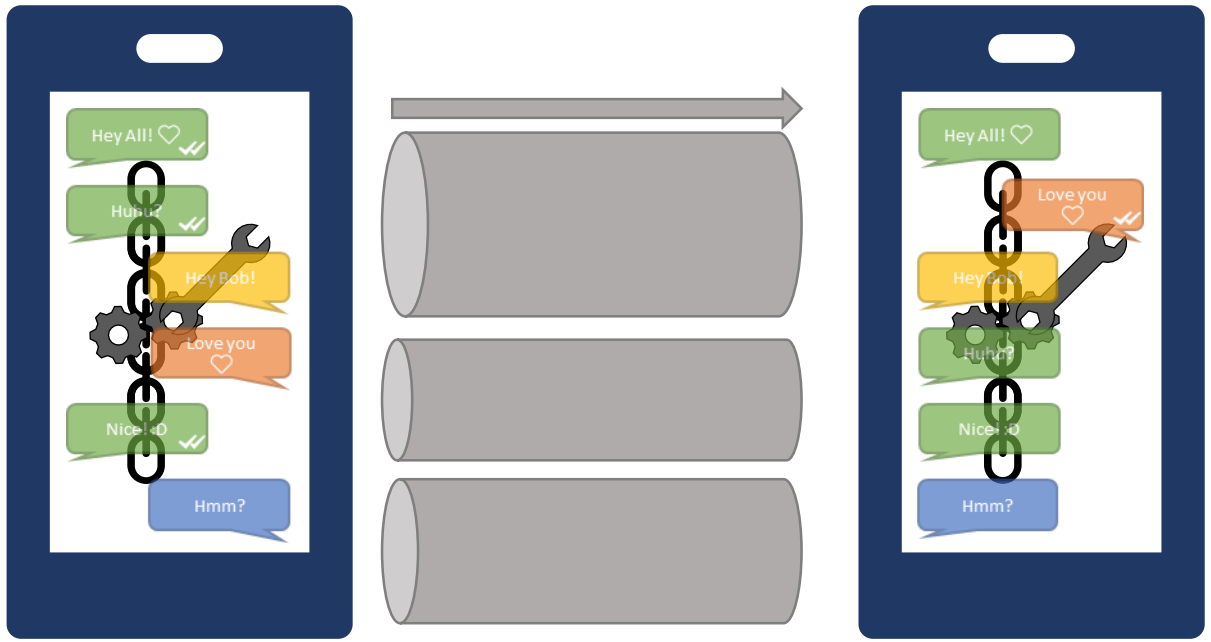
(Strongest) Security definition

- Allow attacker full (defined) power
- Define security property as:
  Event that attacker should not trigger
  Here: attacker guesses exchanged key
- Exclude ways that directly trigger this event (unpreventable attacks)
  - Exposed state of B reveals B's future keys
  - …
- Protocol is insecure if event triggers in remaining cases



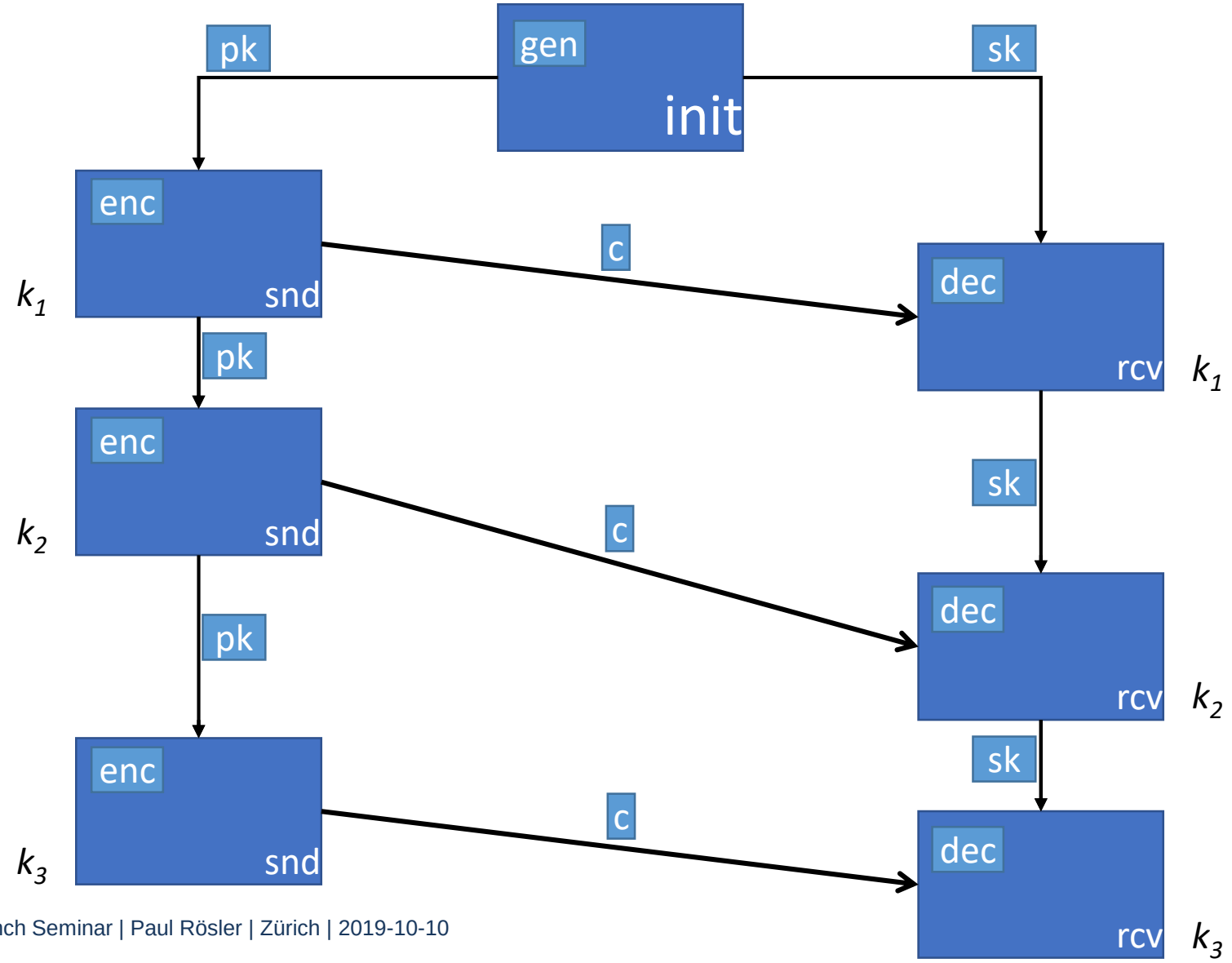
Agenda

- Messaging is complex
- Finding a Syntax
- Understanding Attackers
- Defining Security
- **Understanding Constructions**



Constructing Unidirectional RKE

- Alice: enc(pk)→$ c k
- Bob: dec(sk c)→ k



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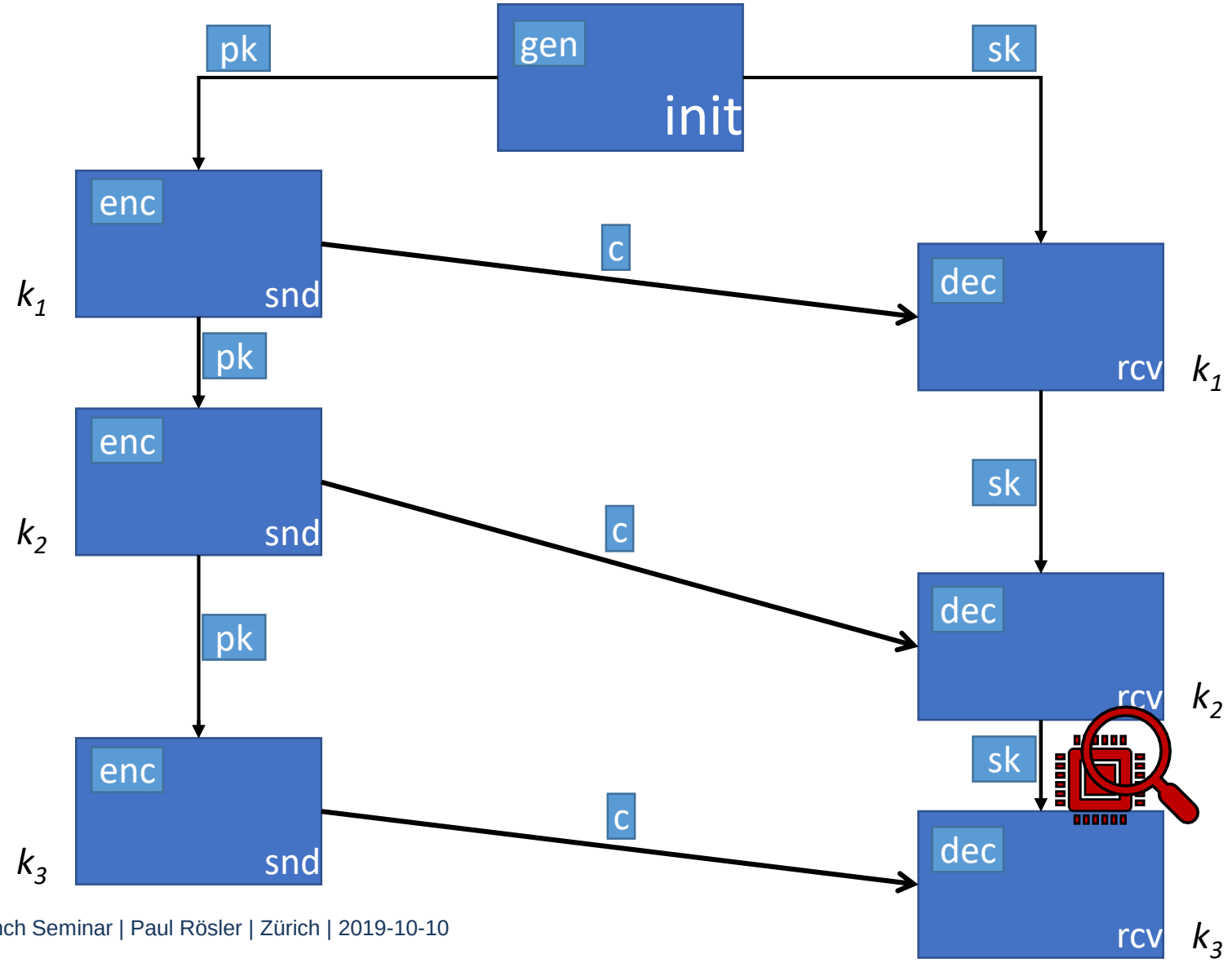

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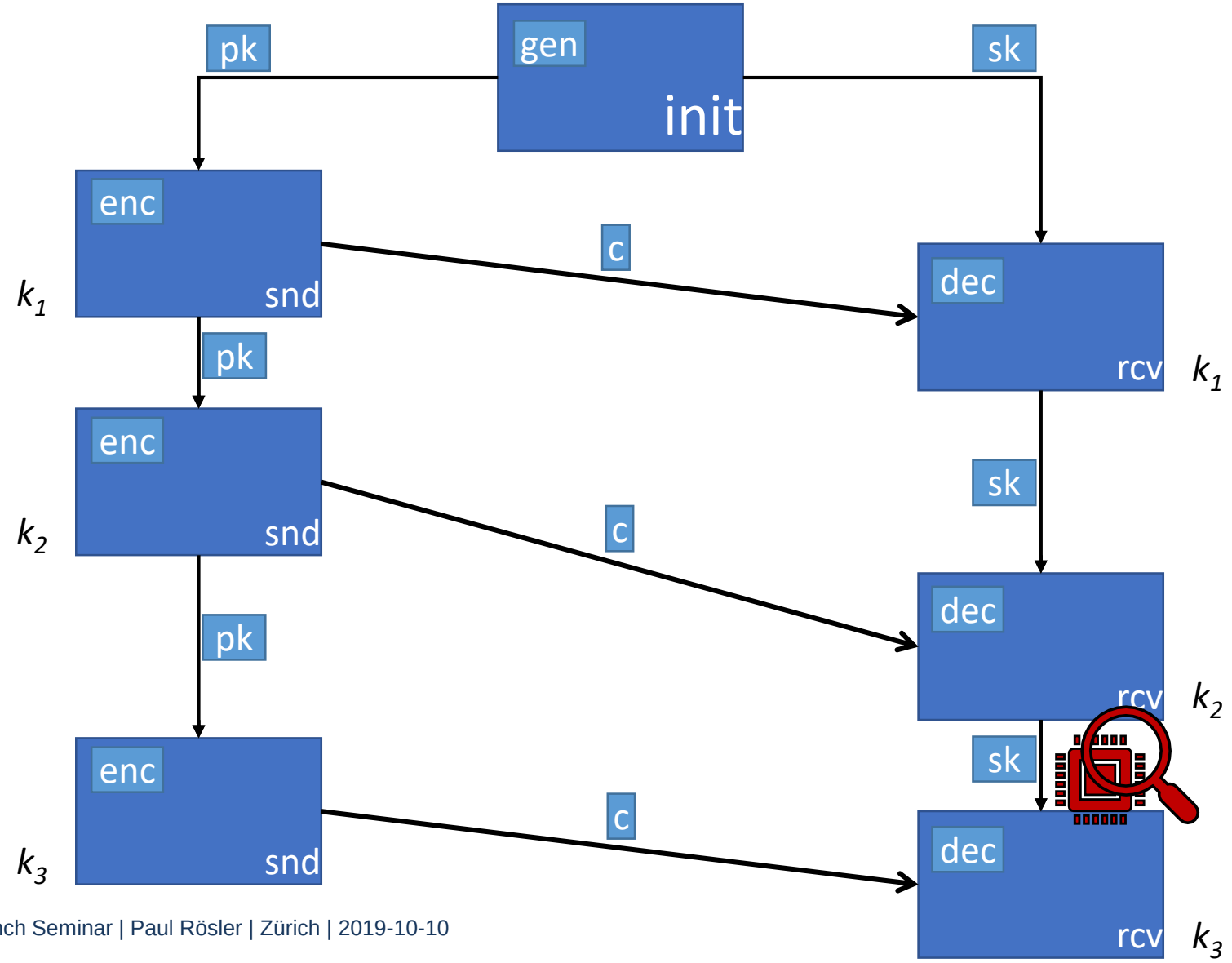

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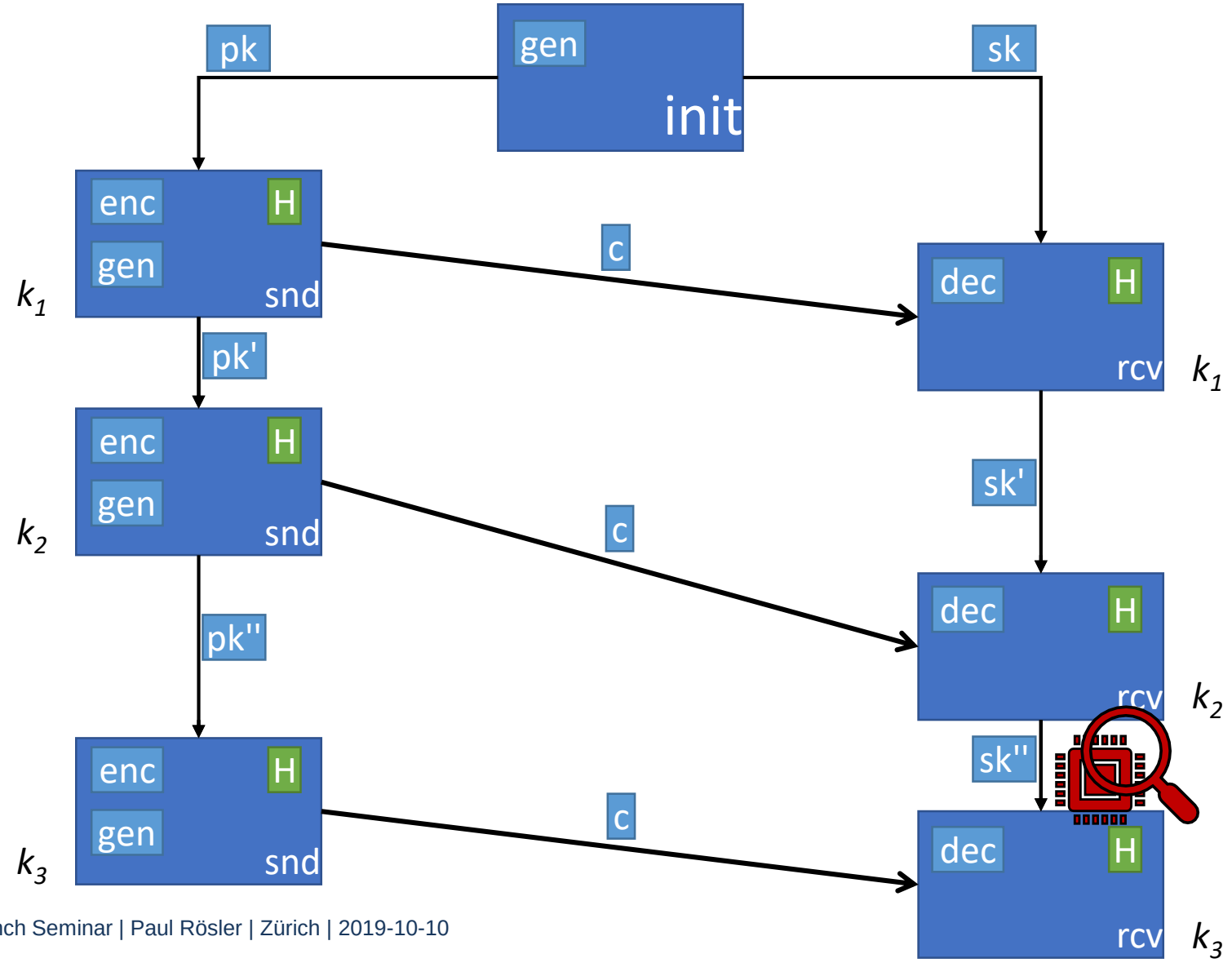

Construction ↔ Security definition

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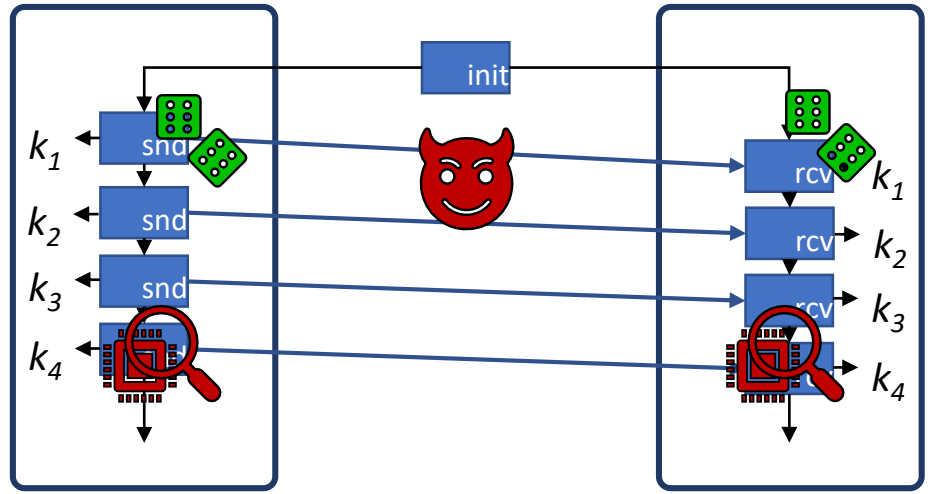
- Many papers with different definitions and different constructions of ratcheting now:



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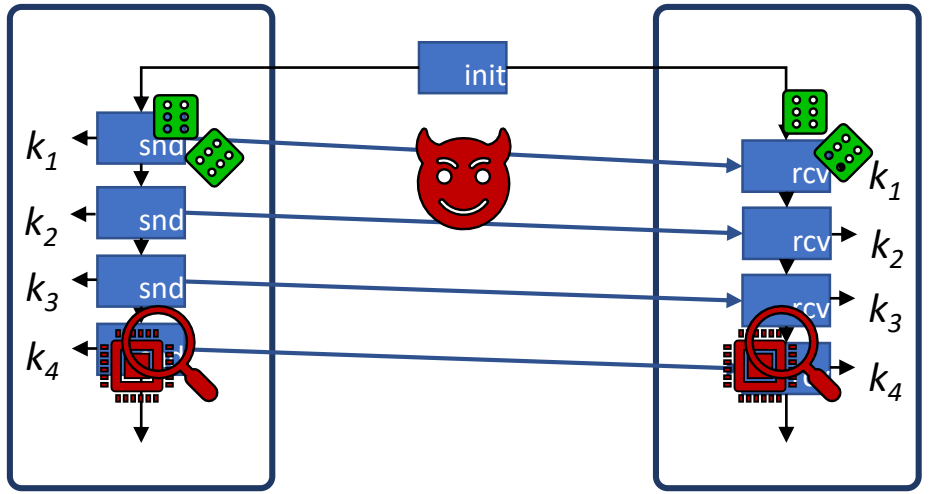
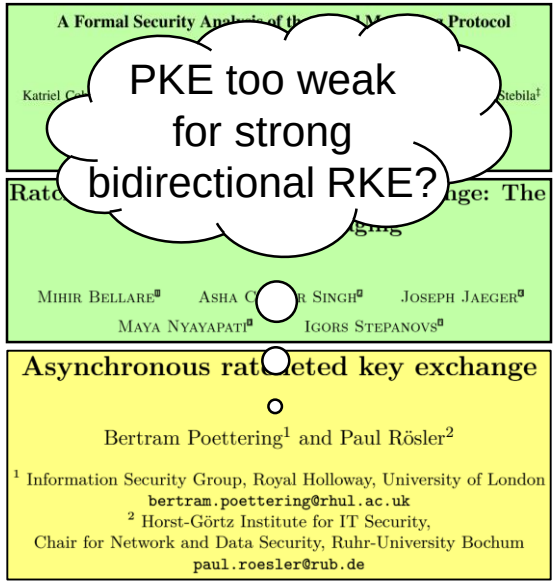
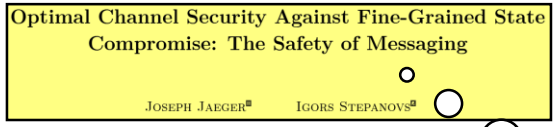
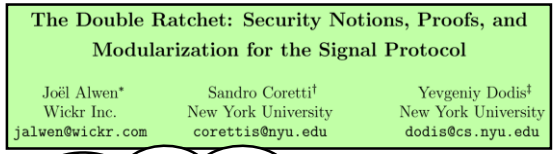
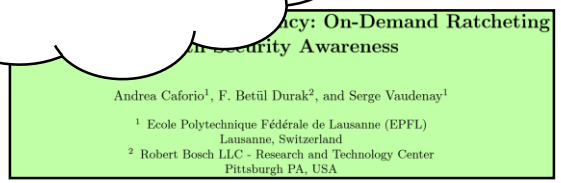
  - "(When) do we need these tools?"
    – Vaudenay, Balli, me











Impact of bad randomness?

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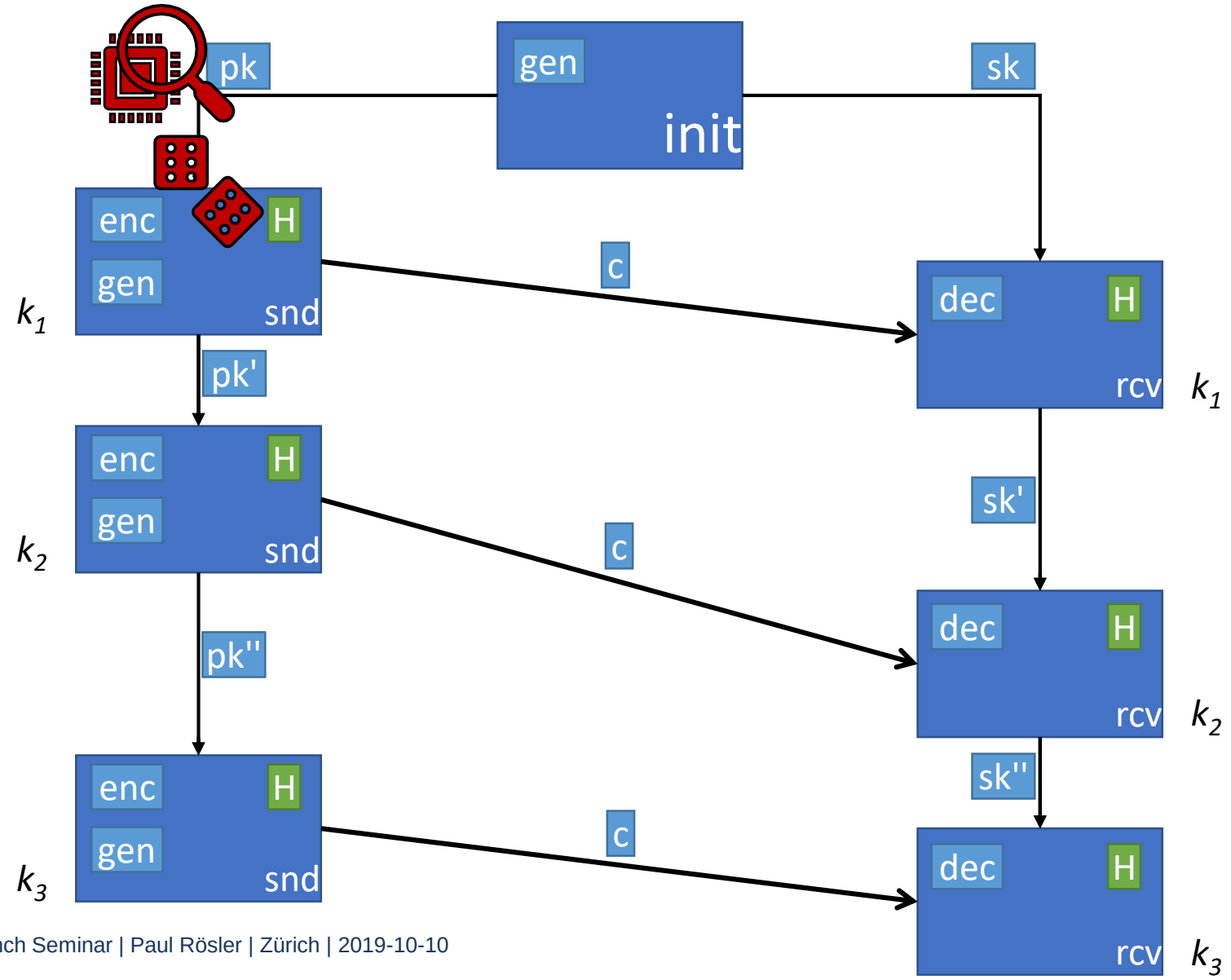

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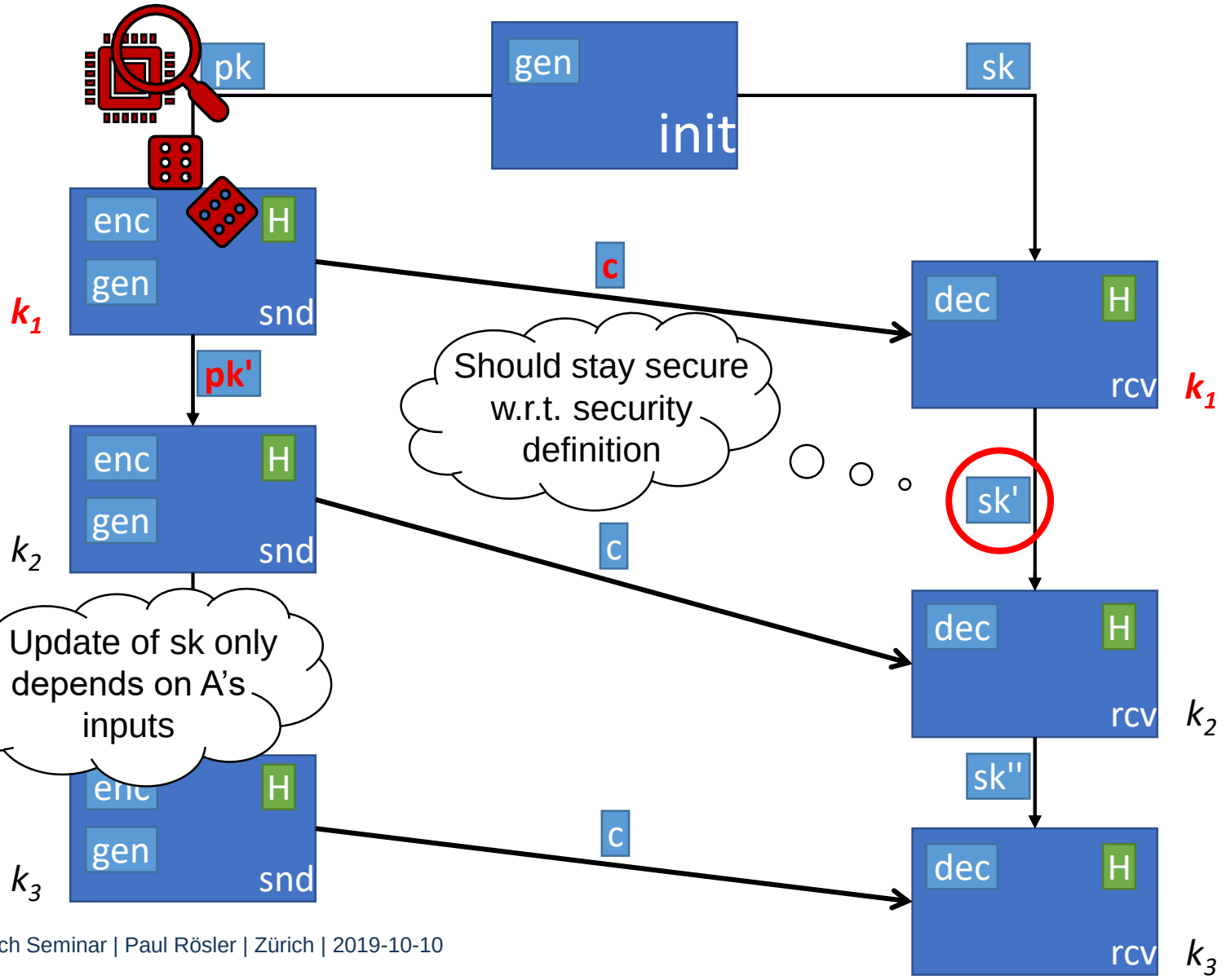

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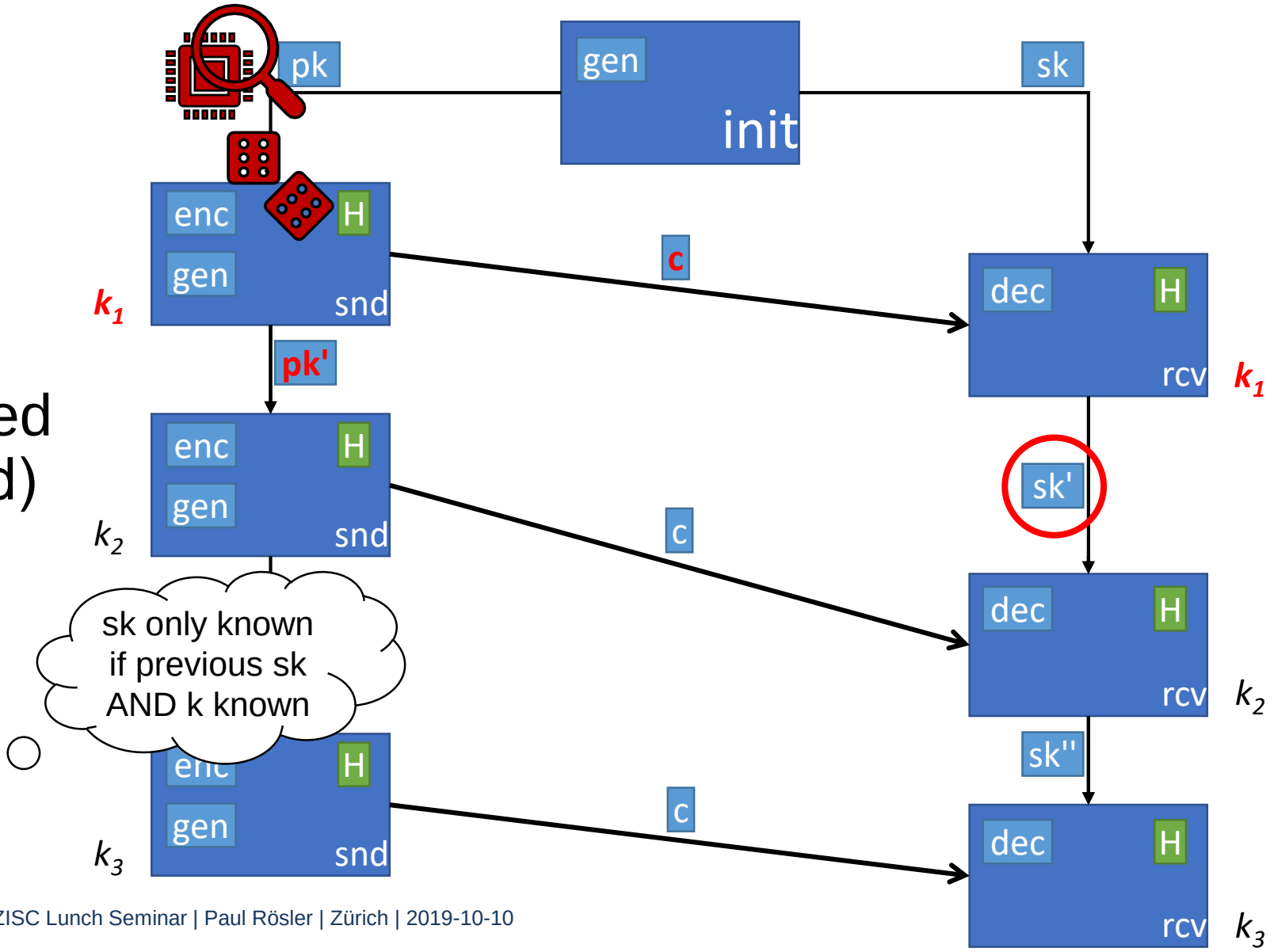

Heavier Tool: key-updatable PKC

- Idea of key-updatable PKC : update pk and sk independently and forward securely
- Based on (expensive) HIBE
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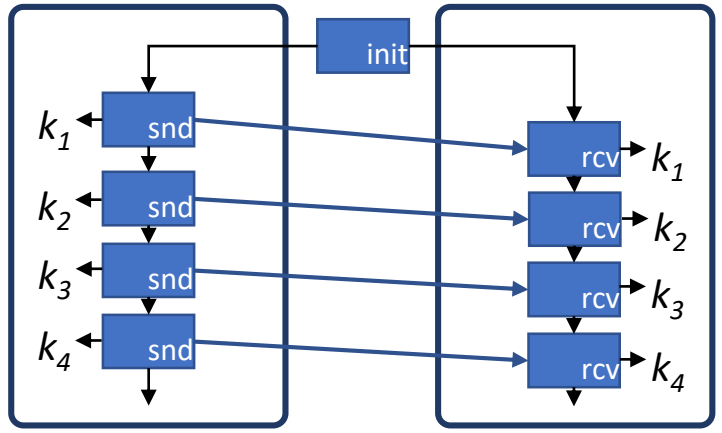

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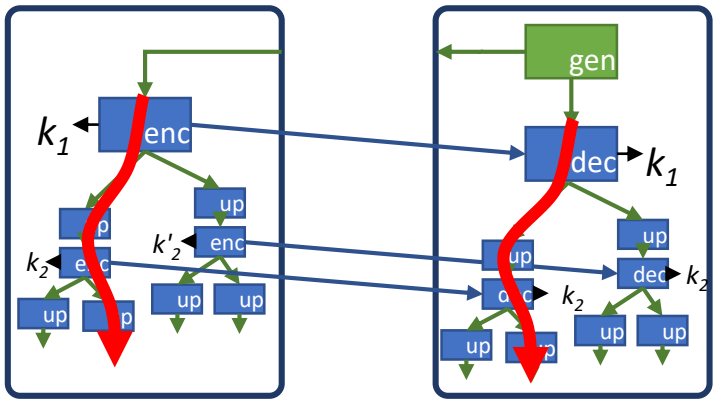

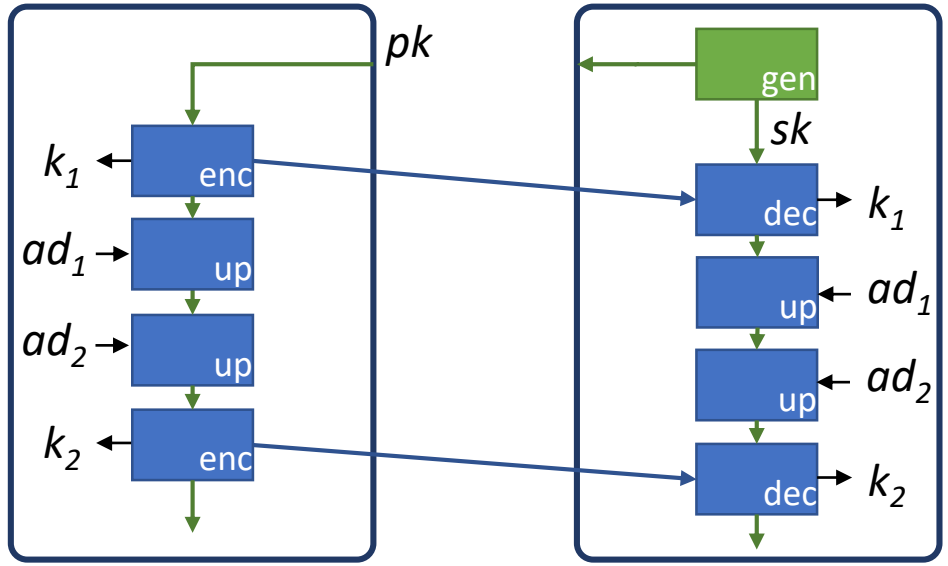

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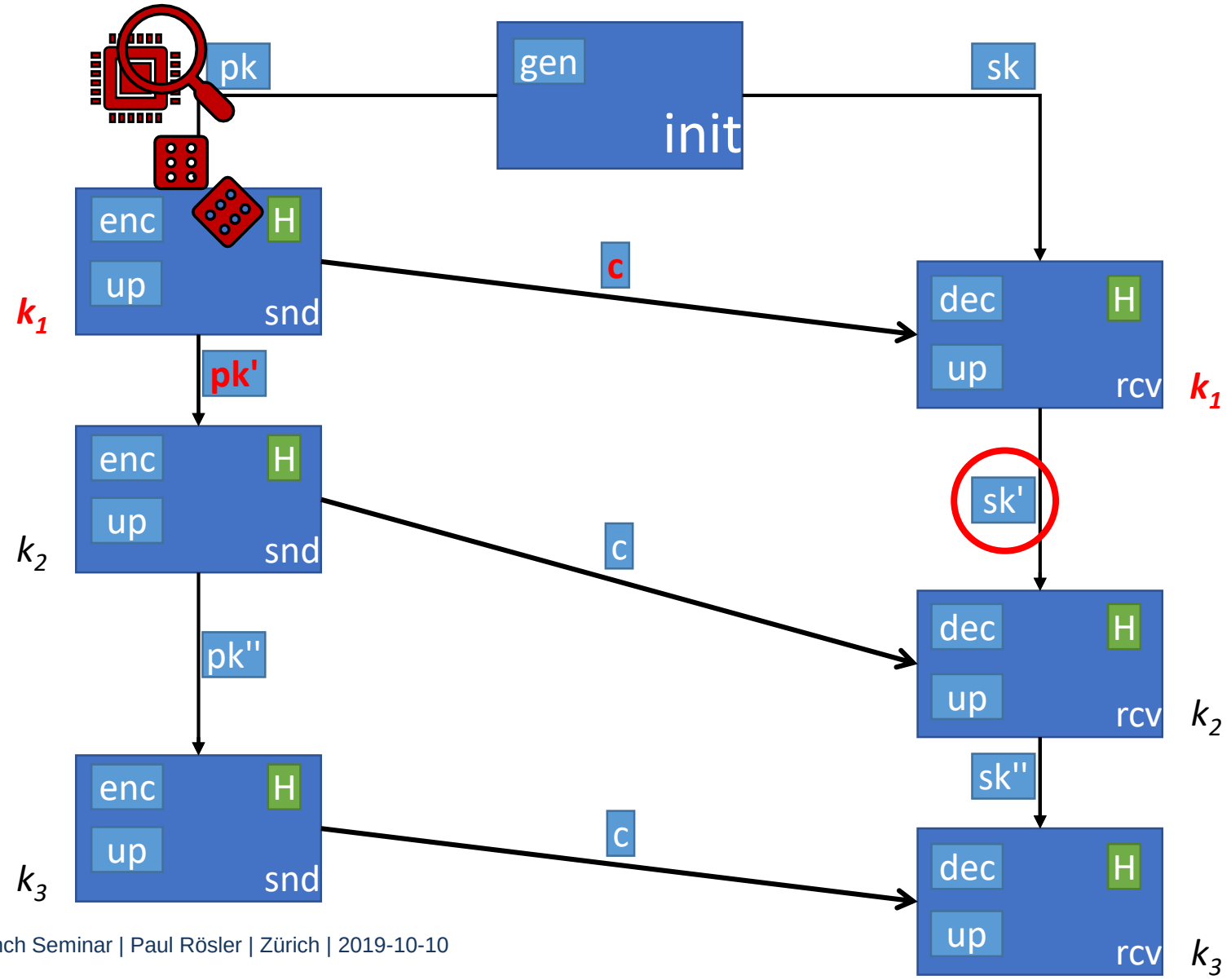

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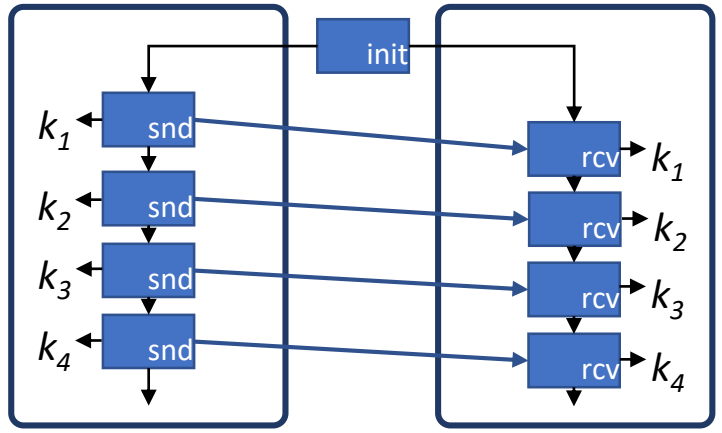

Unpublished work w/ Serge Vaudenay & Fatih Balli

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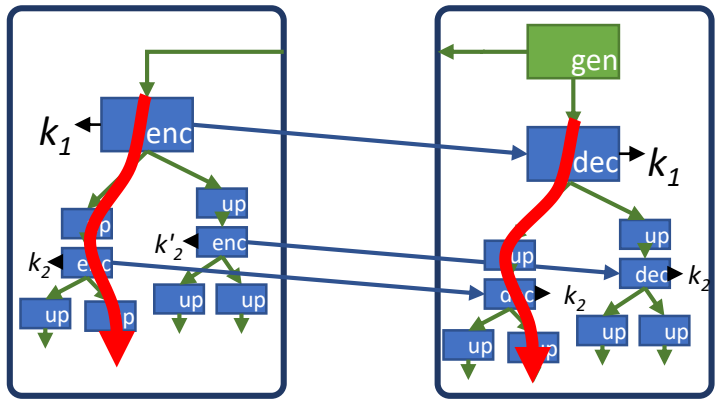

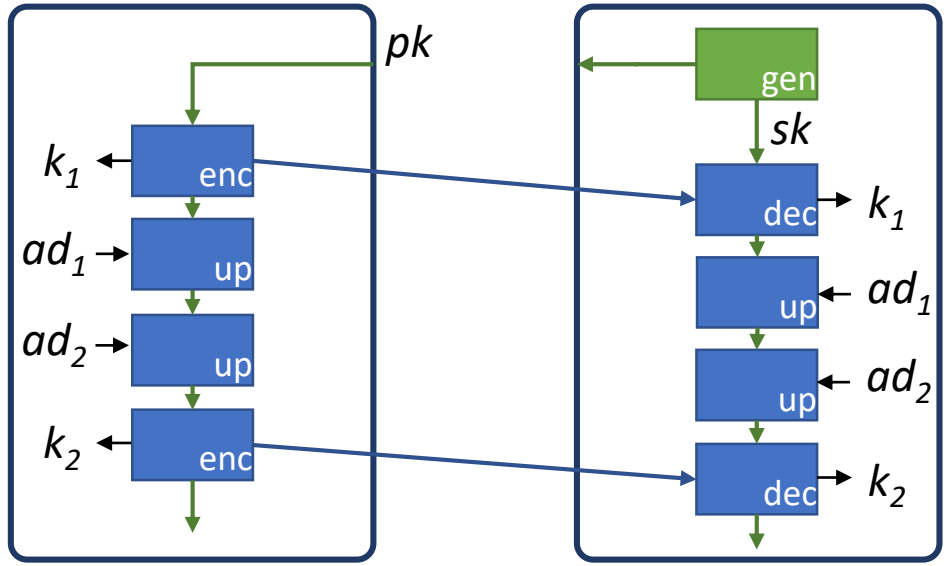

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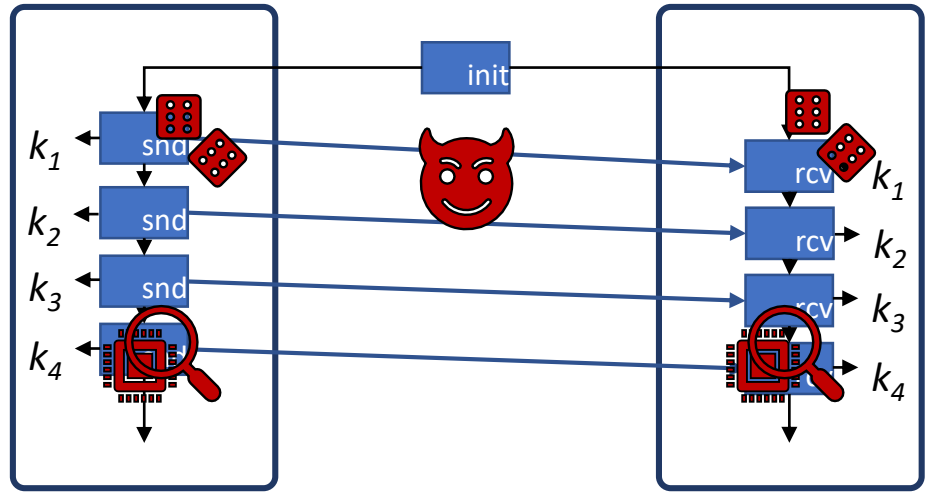

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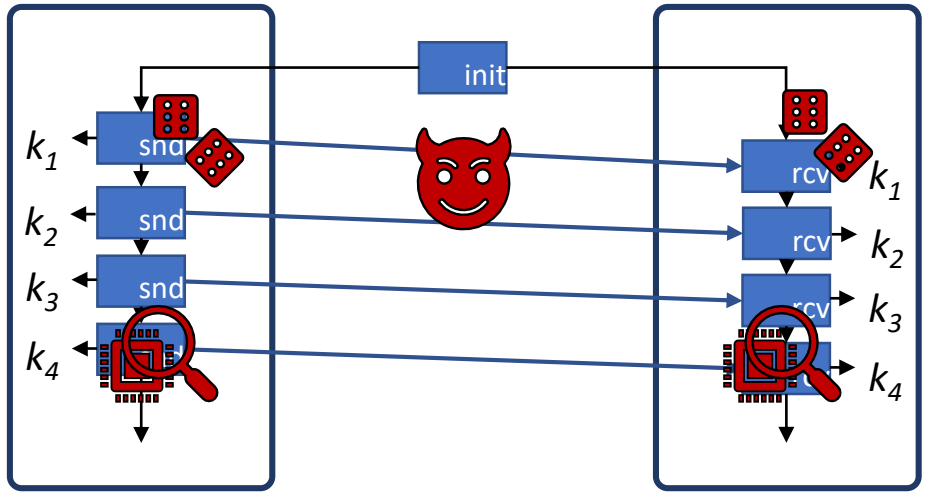

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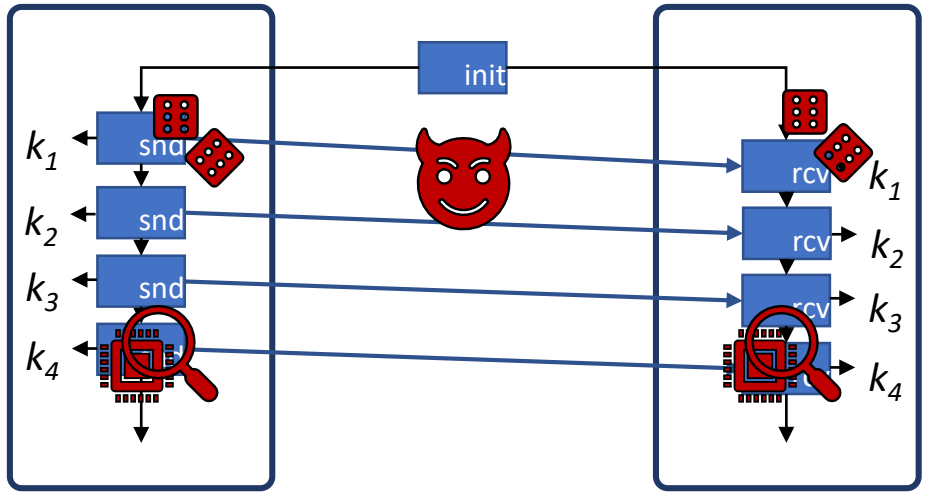

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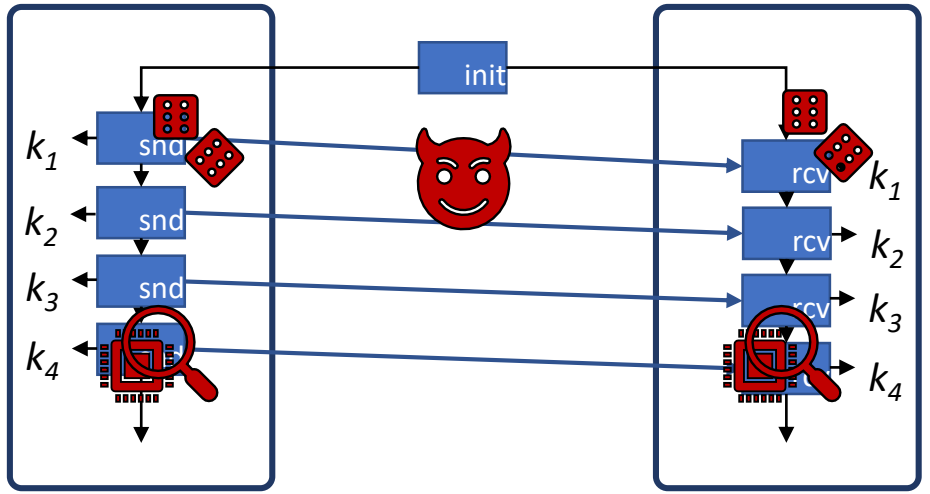

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Asynchronous ratcheted key exchange

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Bidirectional Asynchronous Ratcheted Key Agreement with Linear Complexity*

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Efficient Ratcheting: Almost-Optimal Guarantees for Secure Messaging

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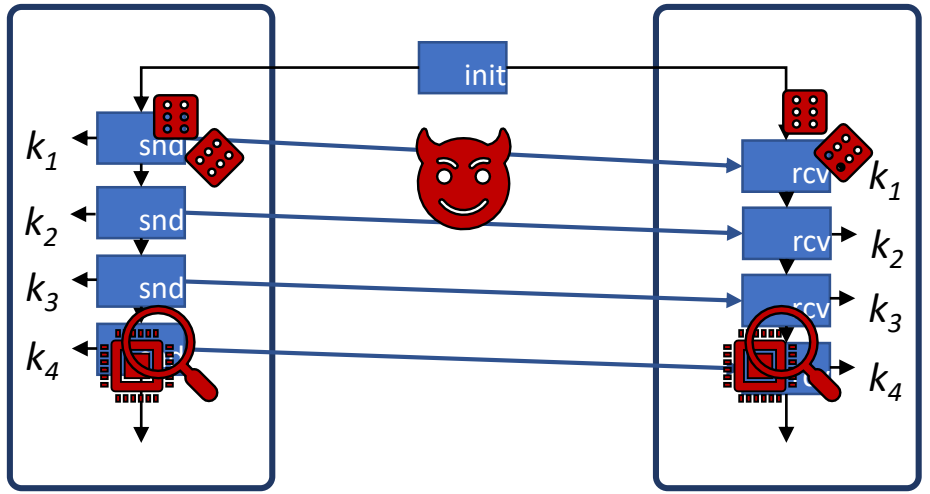

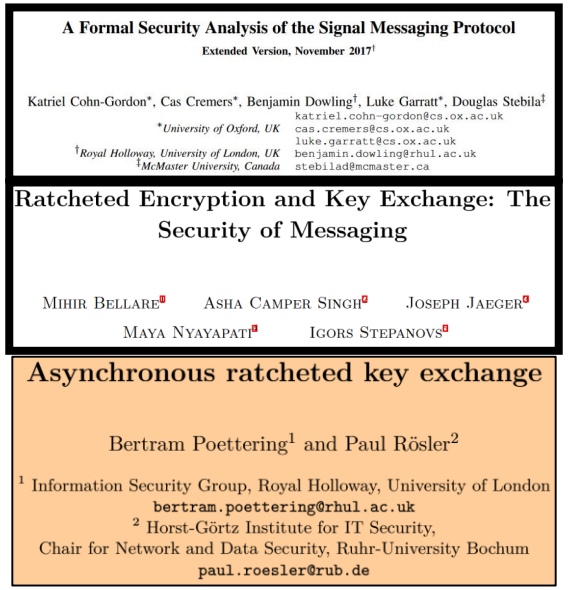
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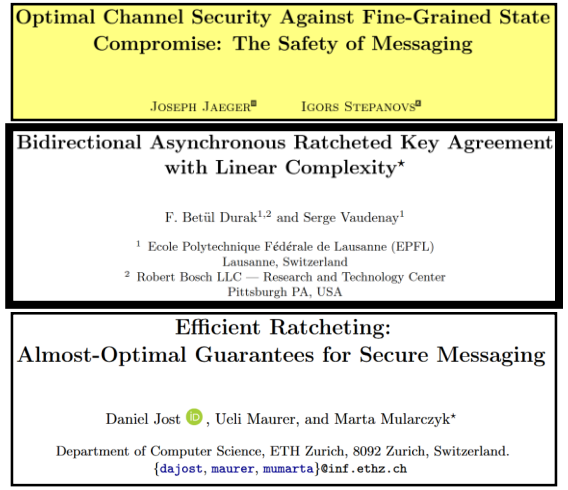
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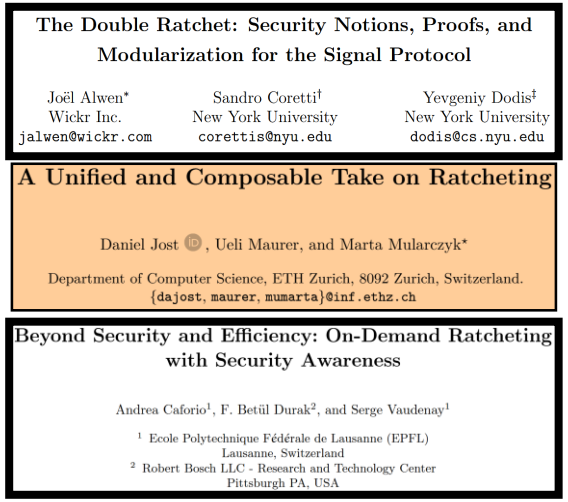
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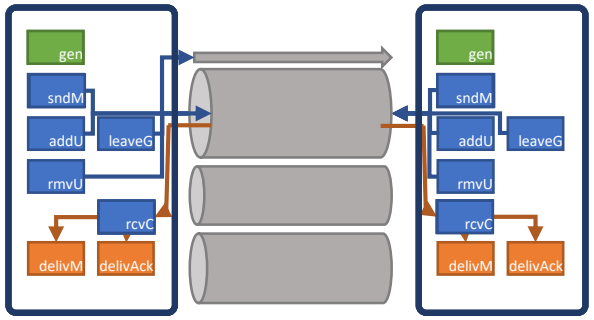
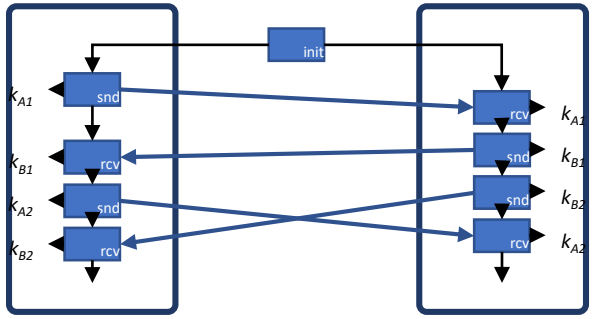
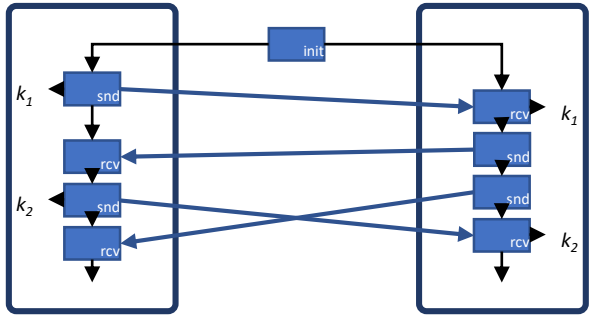
Syntax – Taming complexity



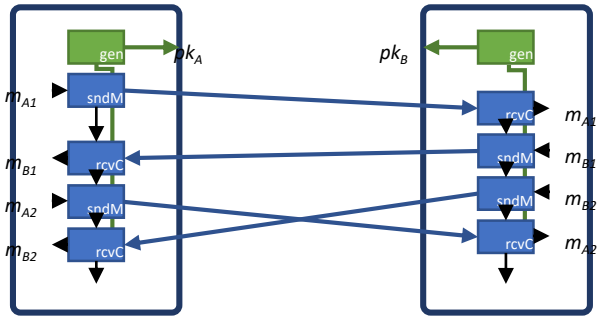


- Copy and merge

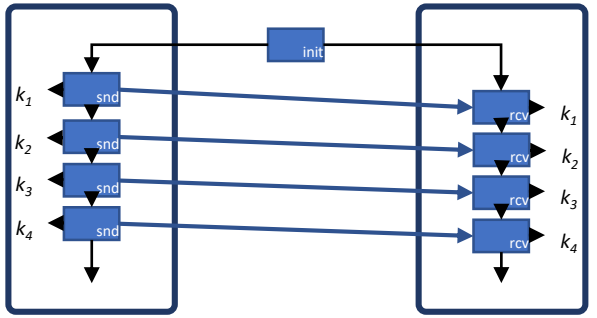
- Initialize with key exchange
- Add authenticated encryption

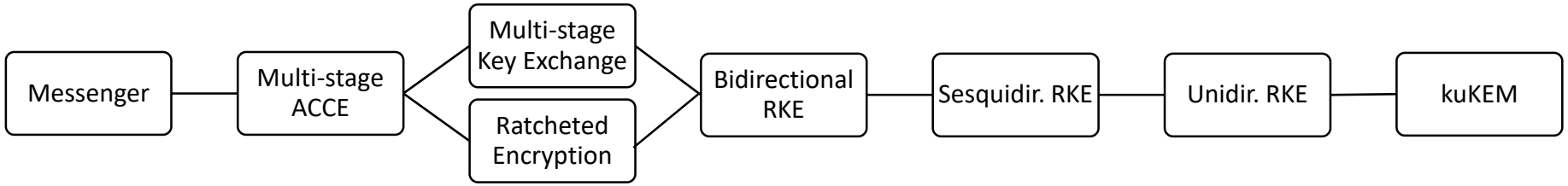


- **N copies and merges (under bad randomness)**



- N pair-wise channels
- Send acks





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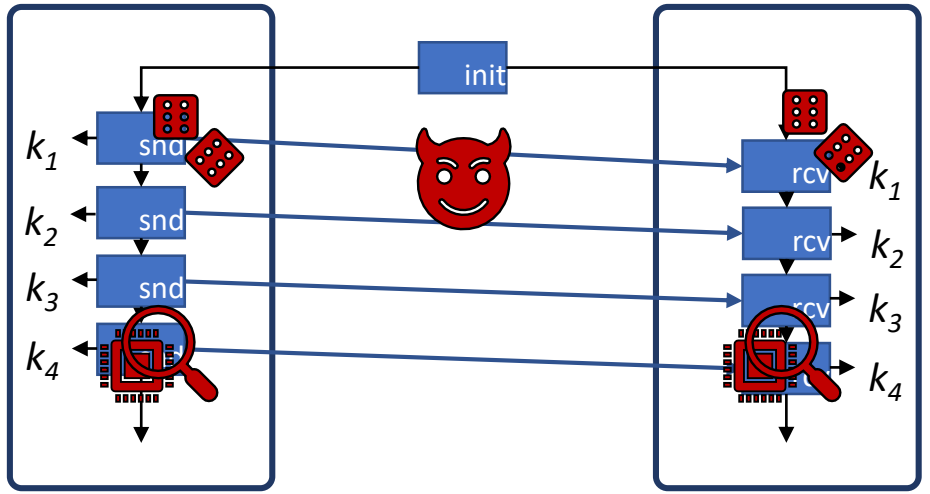

- Open question: bad randomness / bidirectional settings?

ia.cr/2018/296

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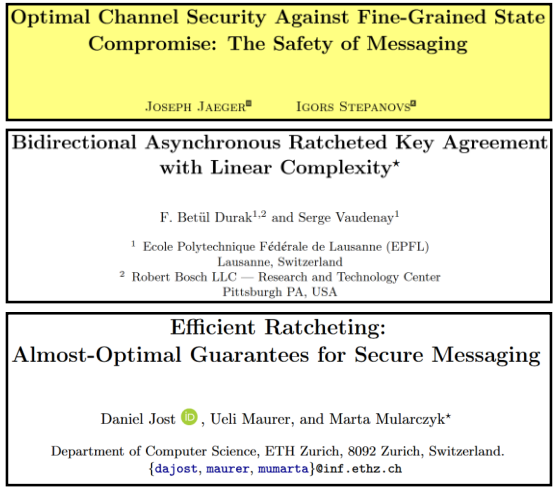

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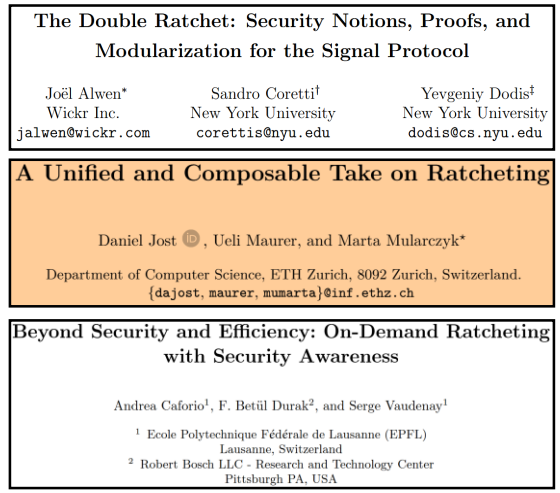

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