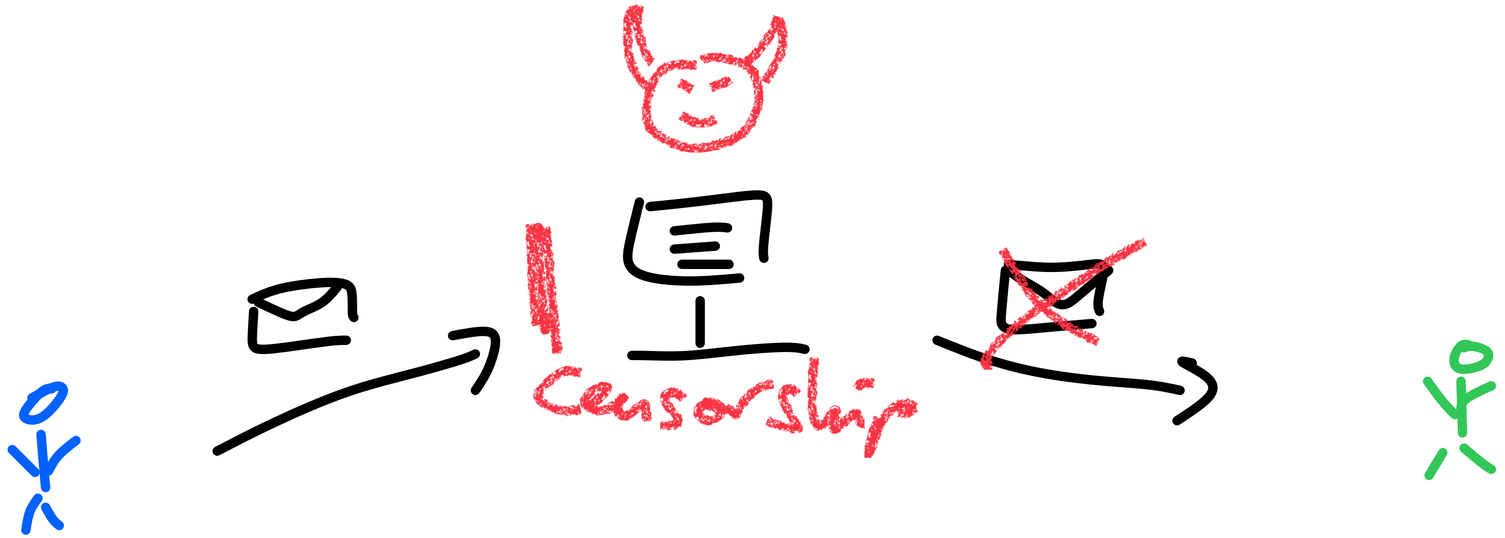
ASMesh: Anonymous and Secure Messaging in Mesh Networks Using Stronger, Anonymous Double Ratchet

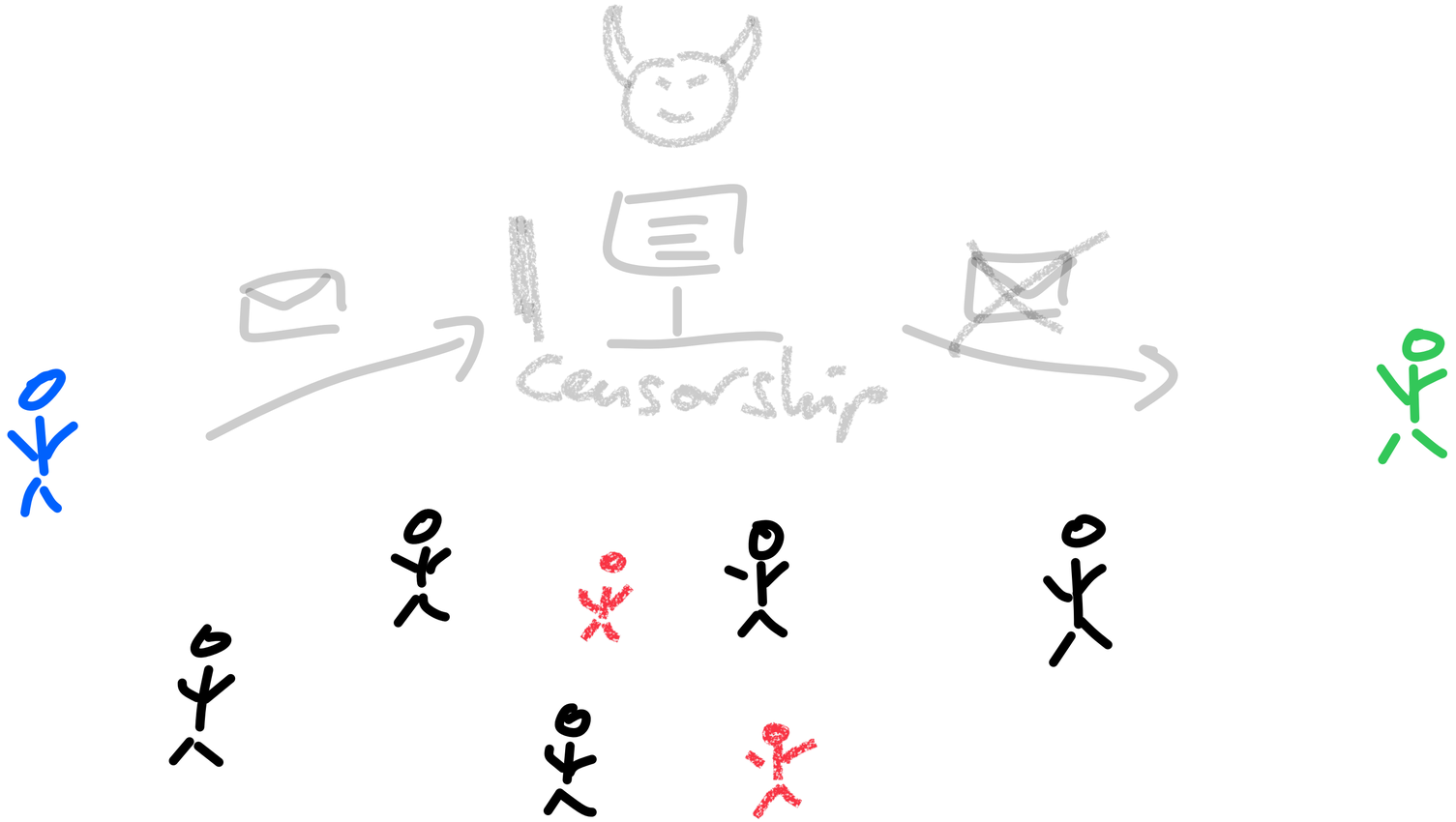
Mathematics and CS Seminar

Paul Rösler 26.09.2023

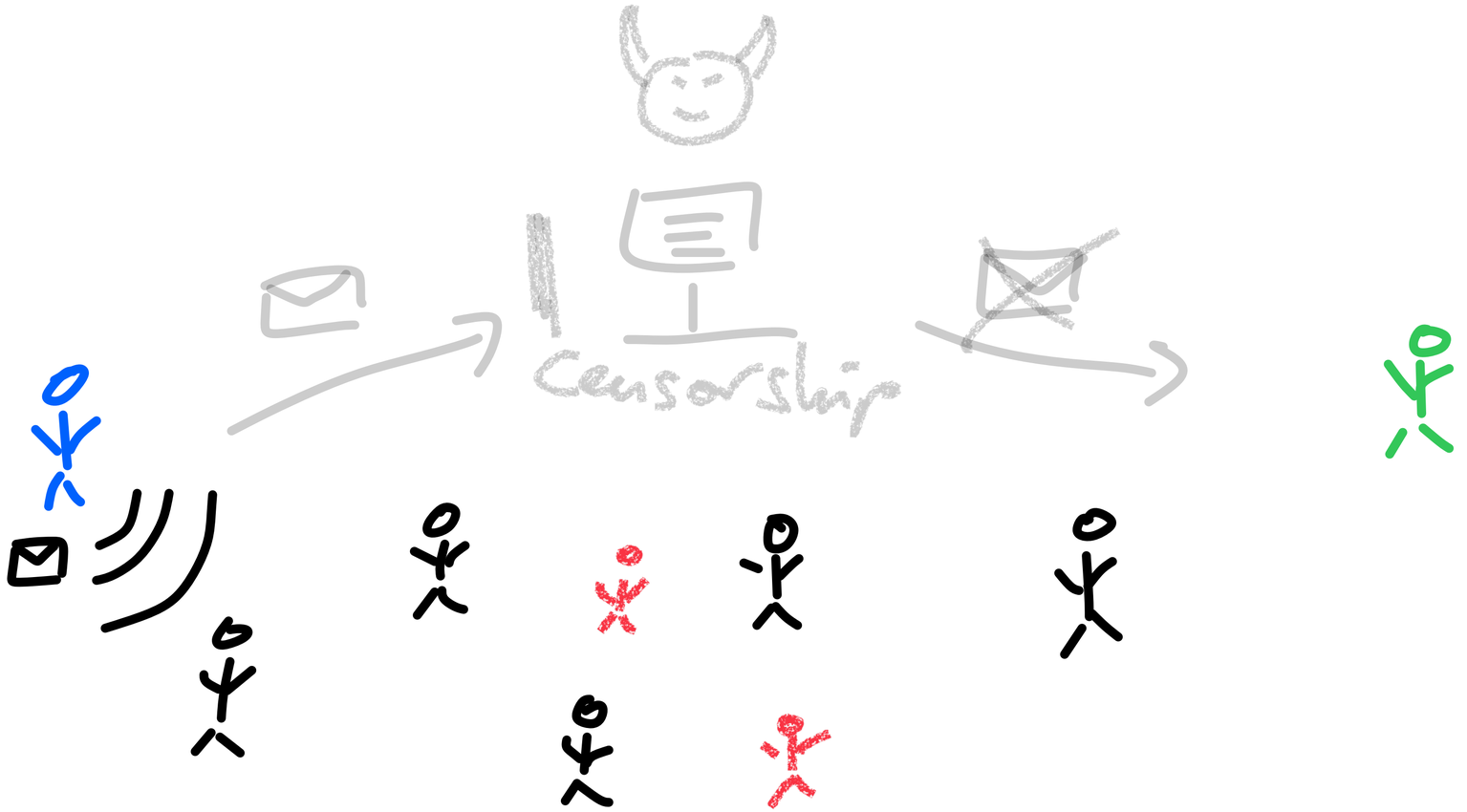
Mesh Networks



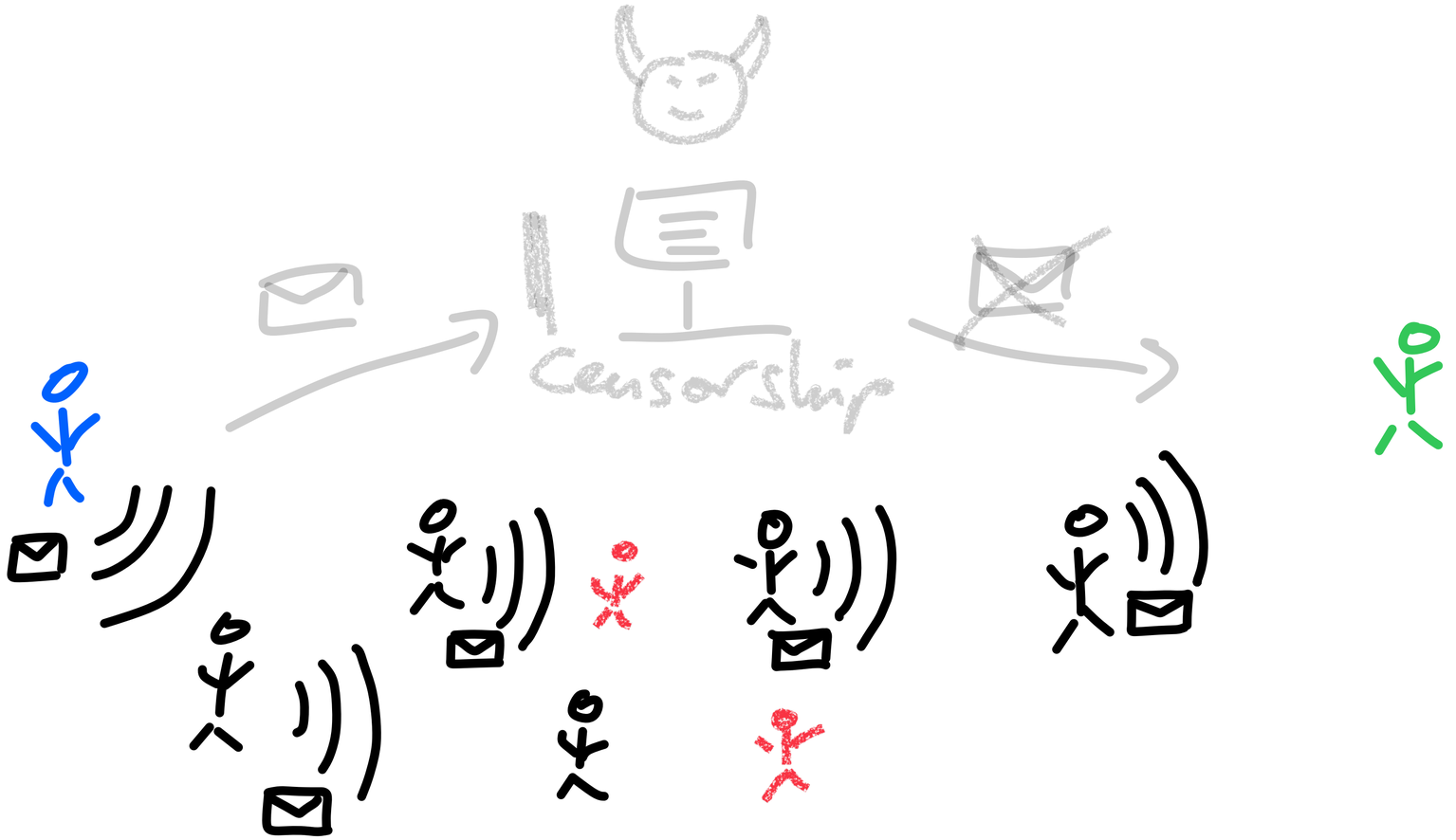
Mesh Networks



Mesh Networks



Mesh Networks



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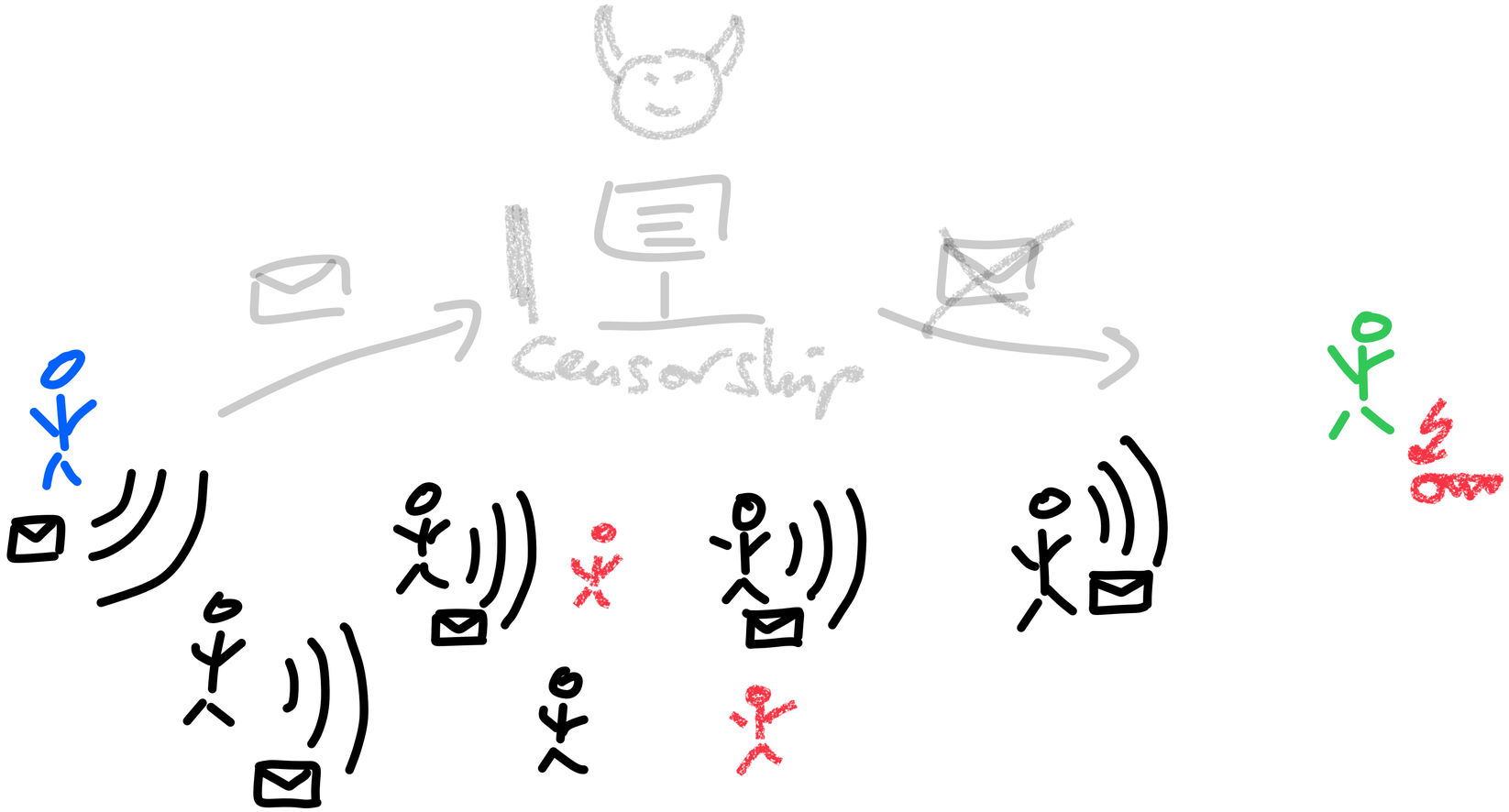

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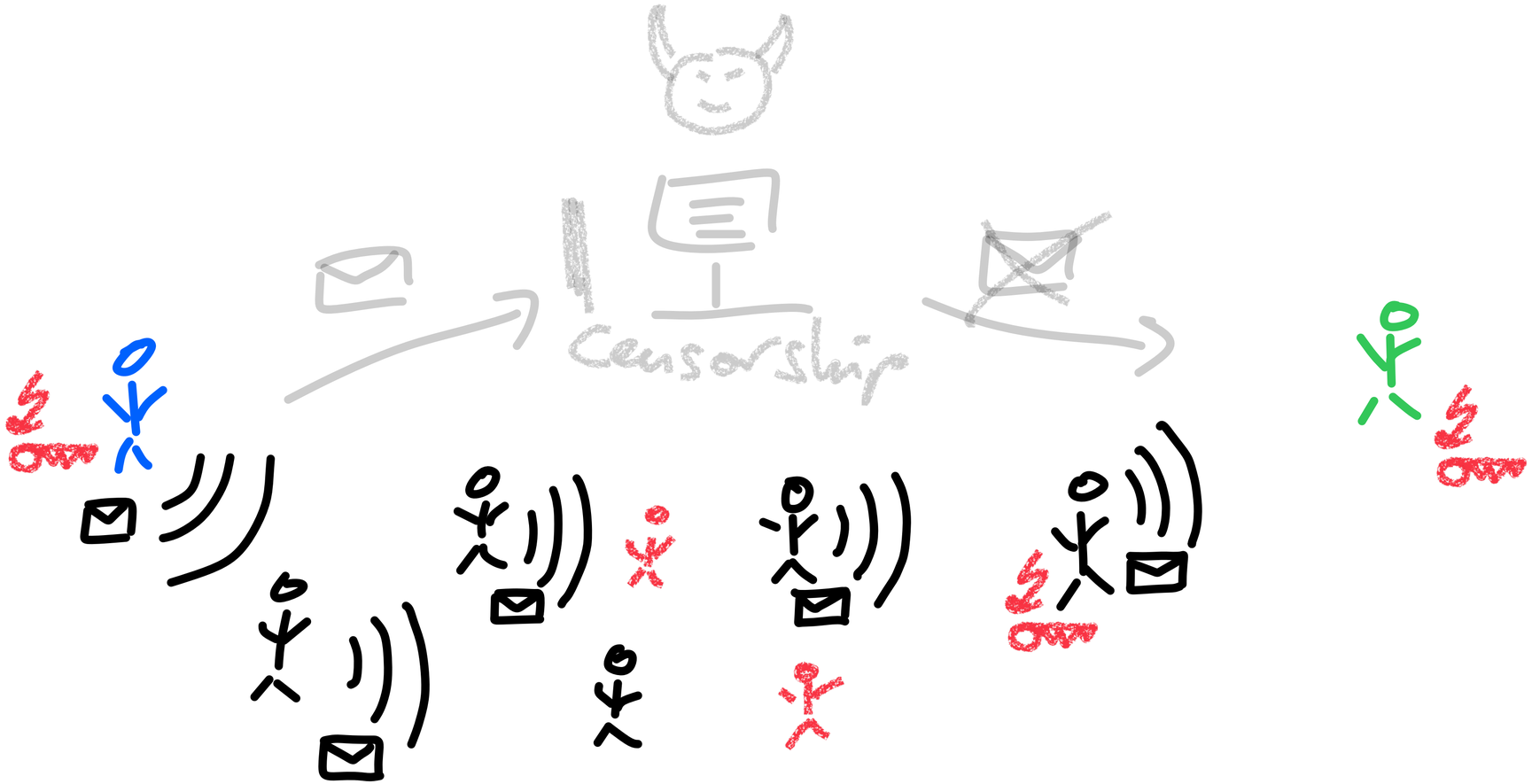
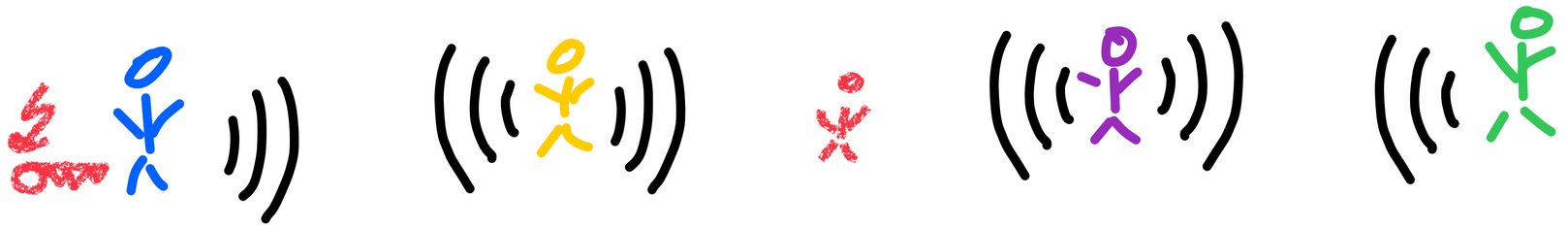
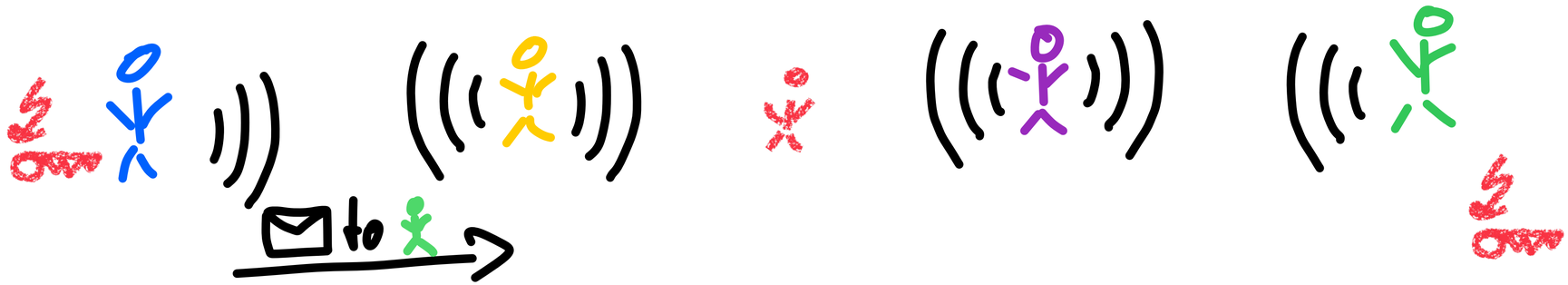


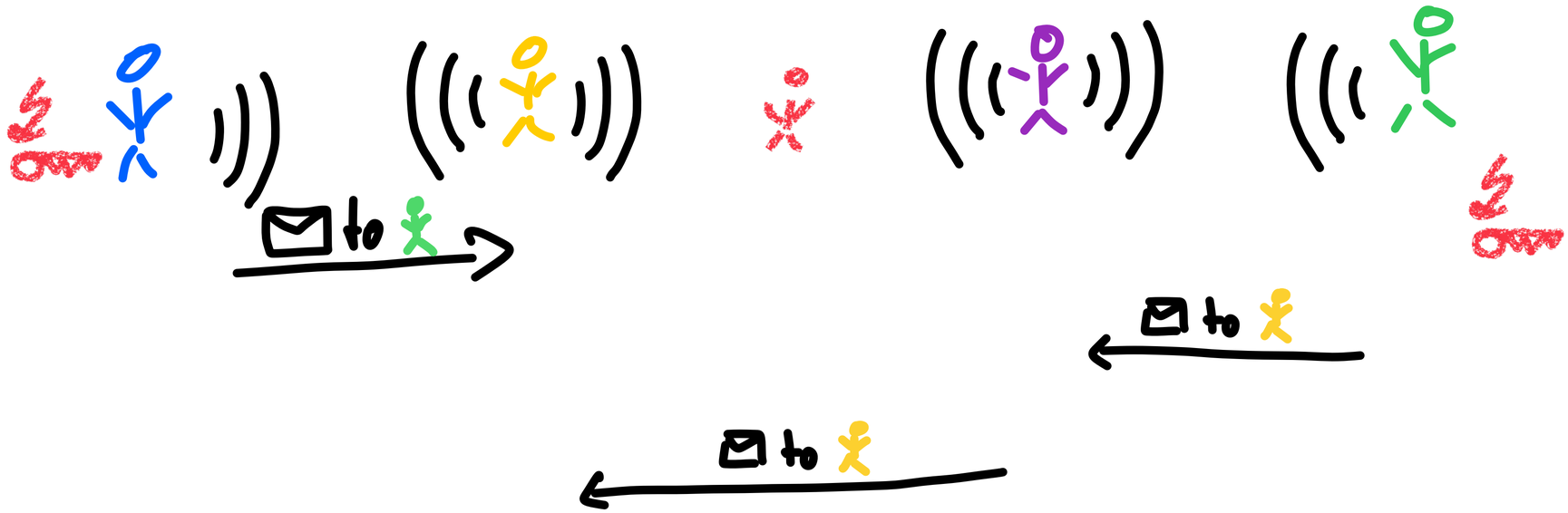
Mesh Networks: Security



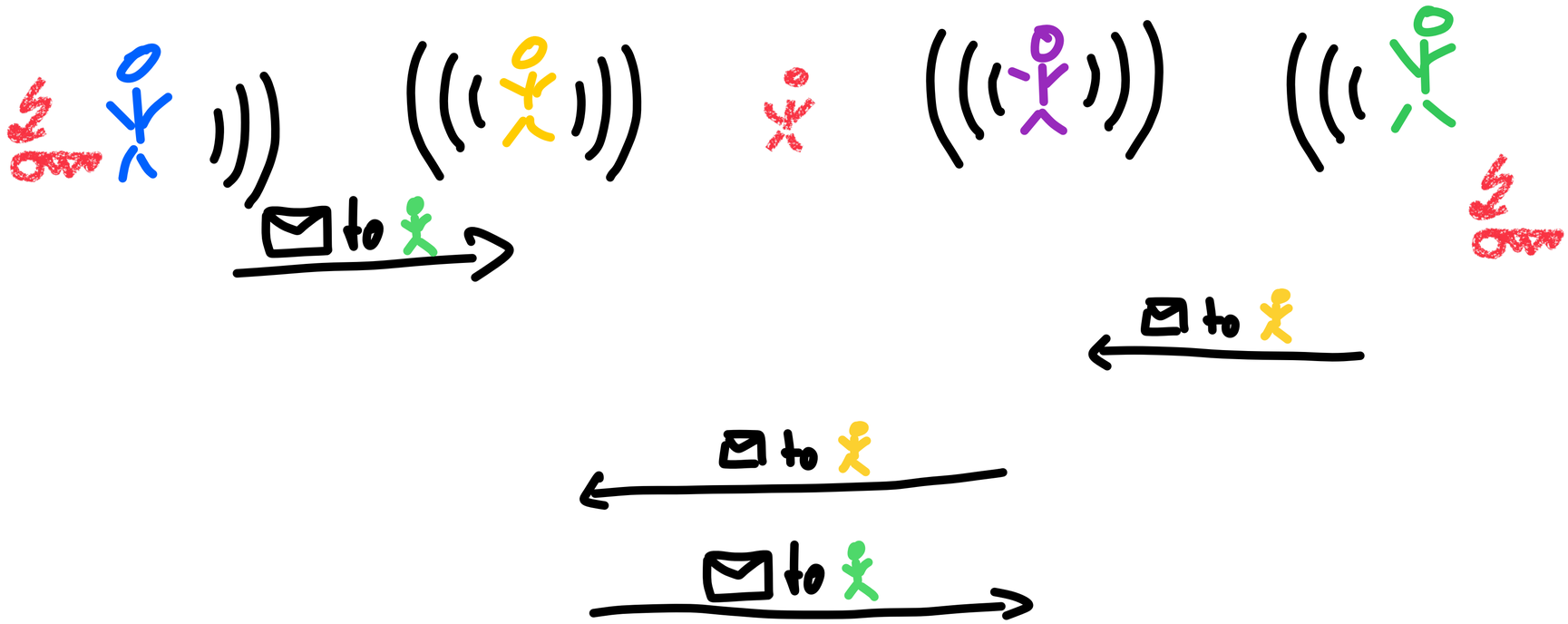
Mesh Networks: Security



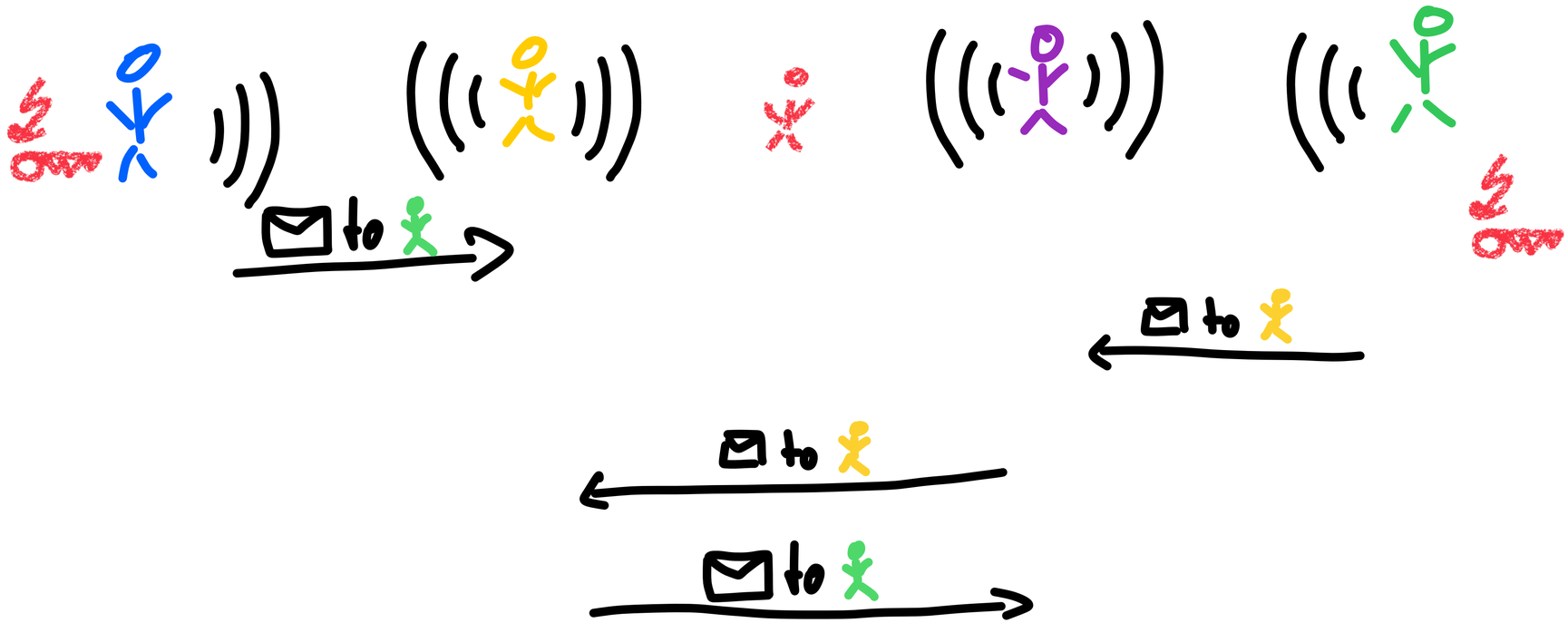
Mesh Networks: Security



Mesh Networks: Security

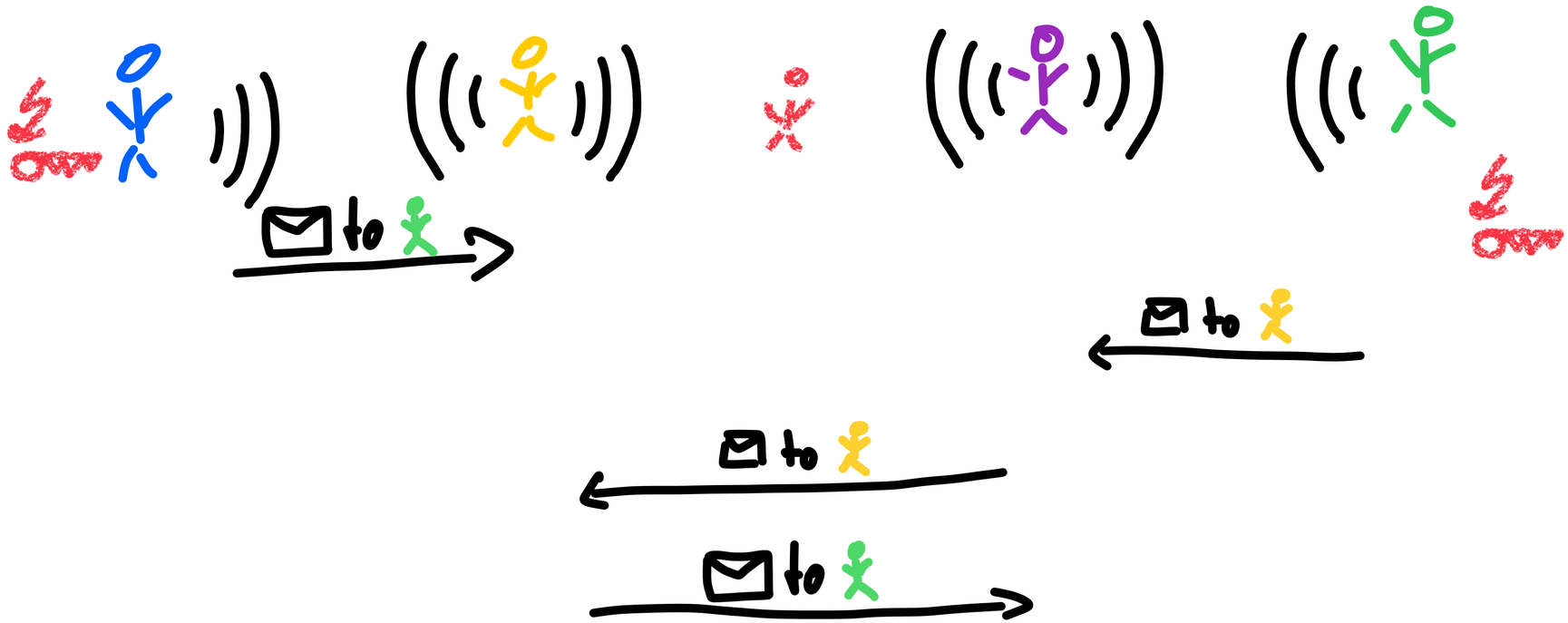


Mesh Networks: Security



Confidential: 's update w/ protocol to "Contact Cooperation"

Mesh Networks: Security



Confidential: 's update w/ protocol to "Contact Cooperation"

Anonymous: 's ID hidden (all sender IDs)

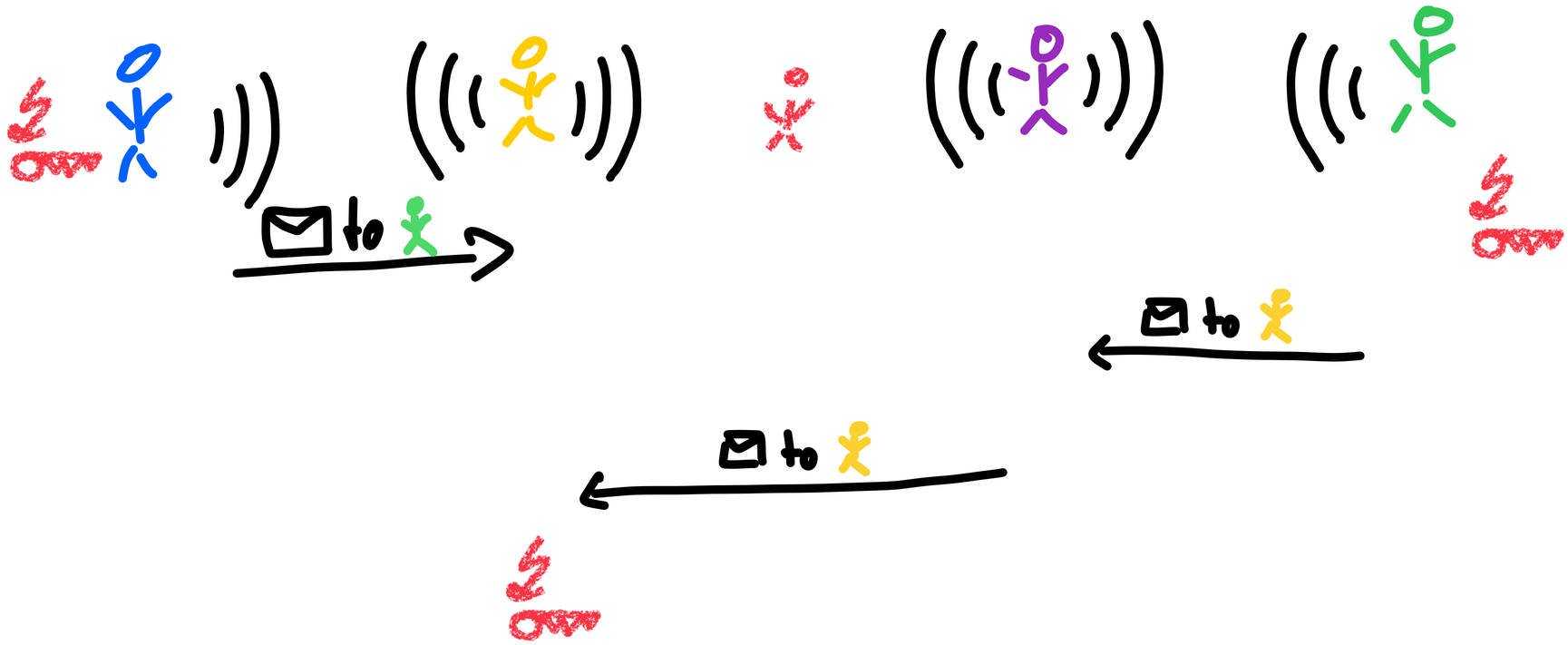
Mesh Networks: Security

Confidential: 's update w/ protects to "Contact Cooperation"

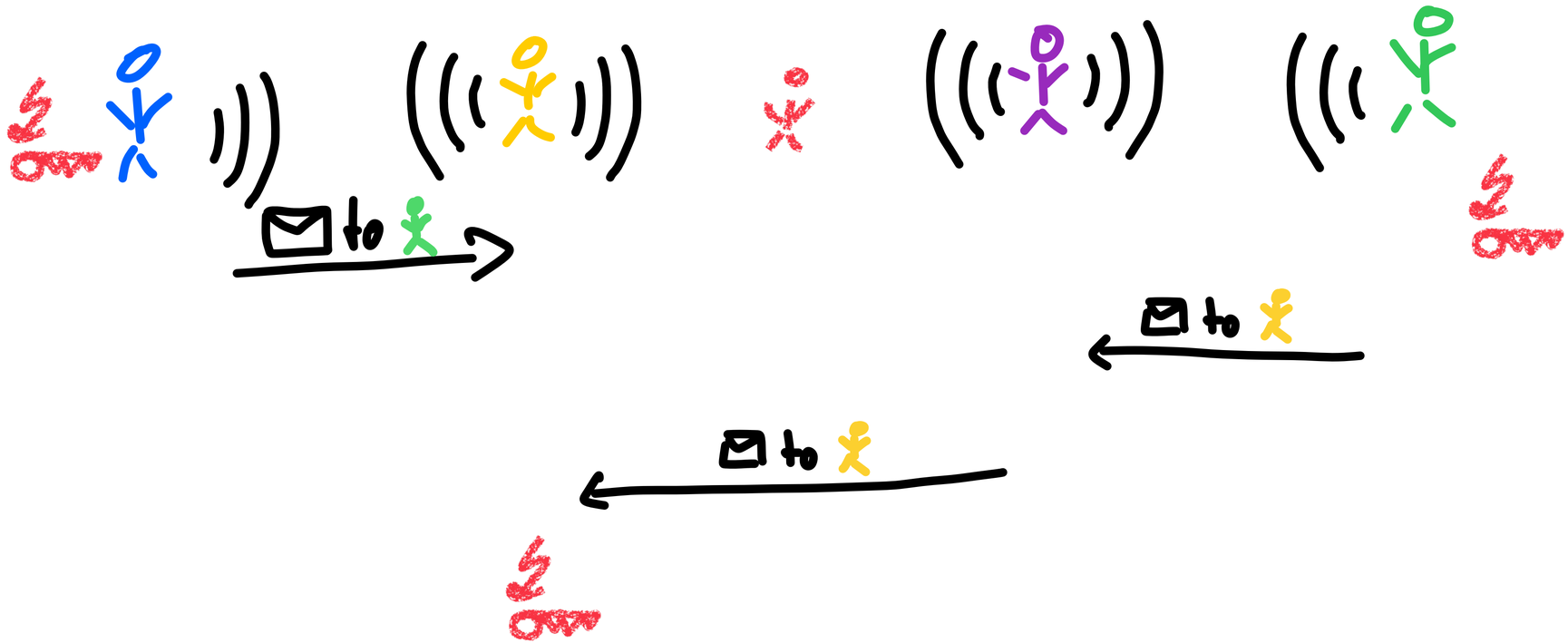
Anonymous: 's ID hidden (all sender IDs)

Alternative: Full Anonymity w/o Contact Cooperation

Mesh Networks: Security Model



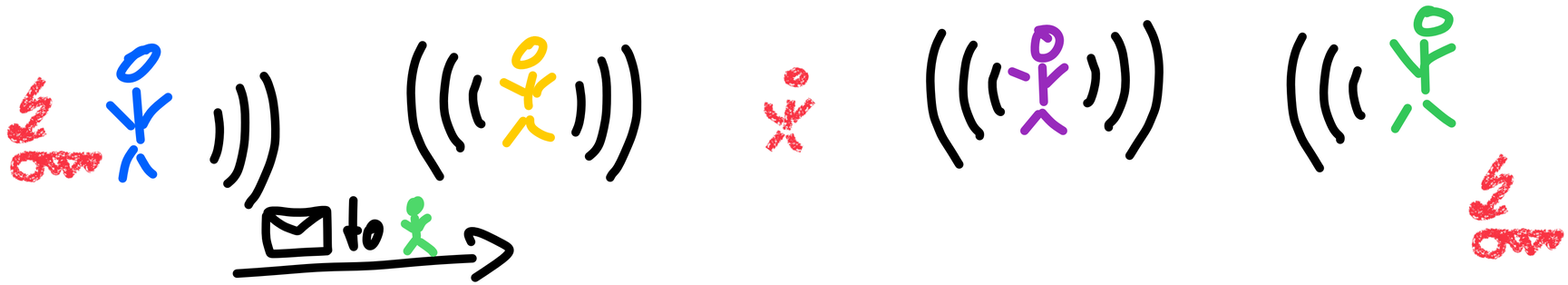
Mesh Networks: Security Model



Exposed State contains "Anonymous Challenge Ciphertext"

↳ Embedded construction dependent

Mesh Networks: Security Model



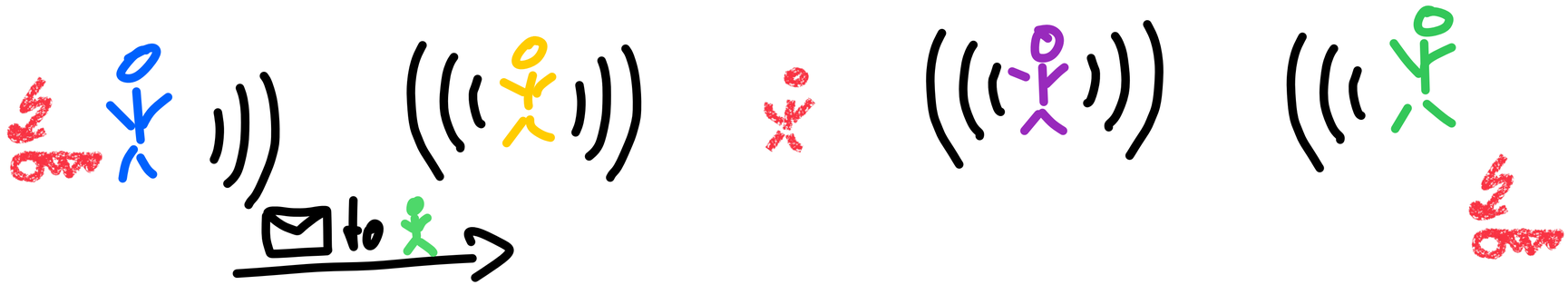
Exposed State contains "Anonymous Challenge Ciphertext"

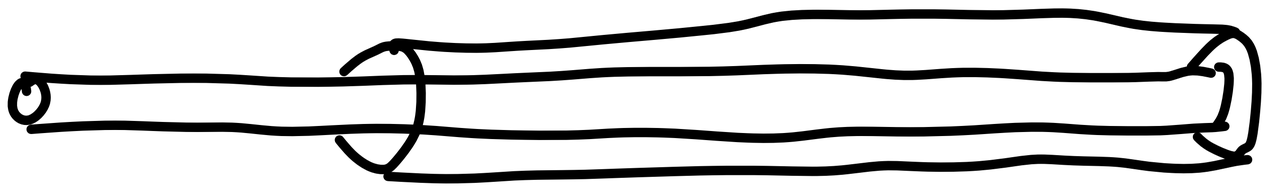
↳ Embedded construction dependent

↳ Unnatural for frame-based Model

↳ Simulation-Based

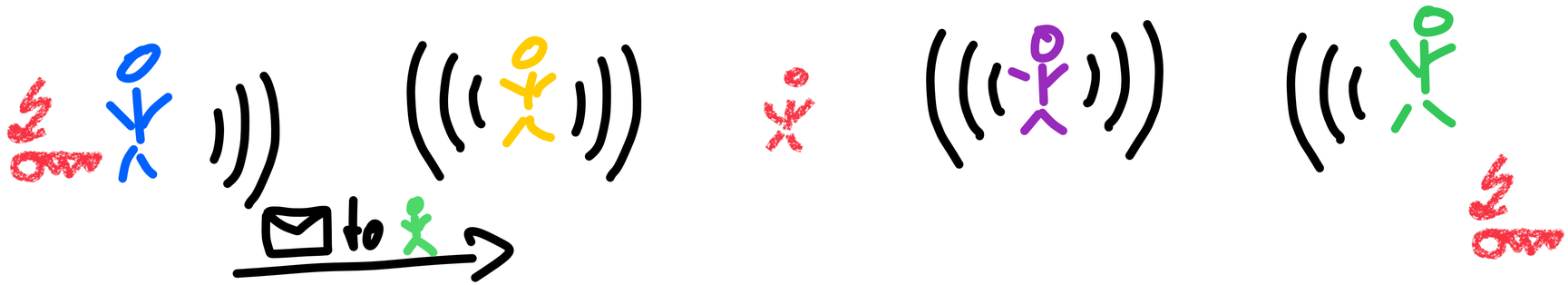
Mesh Networks: Construction

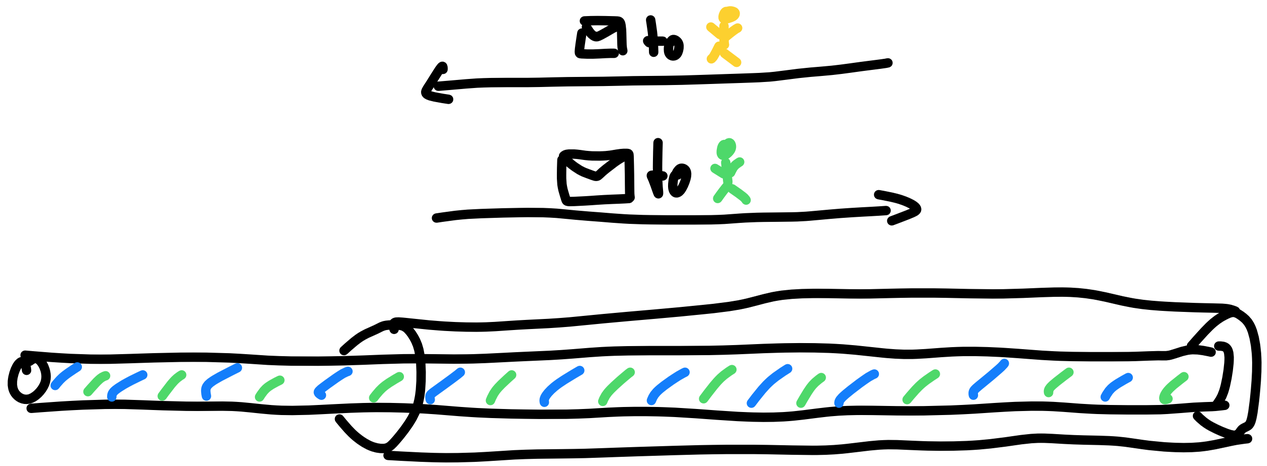




Nested Double Ratchet

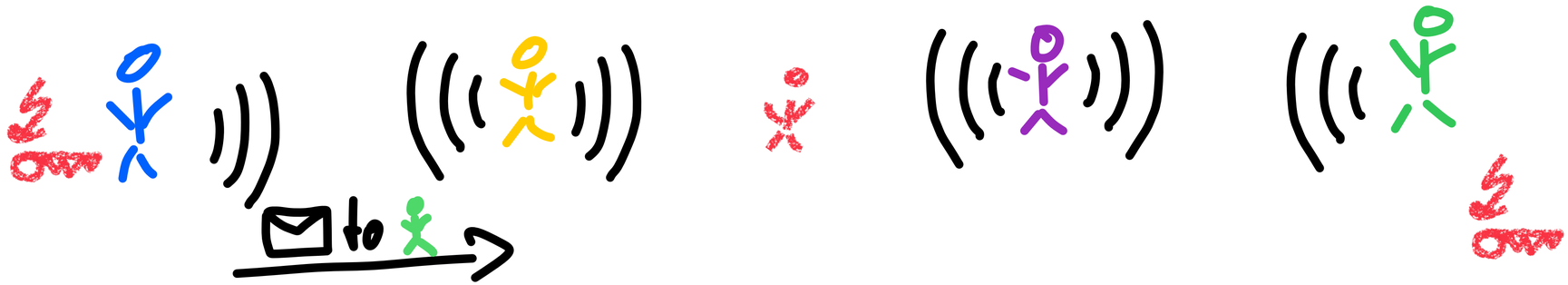
Mesh Networks: Construction

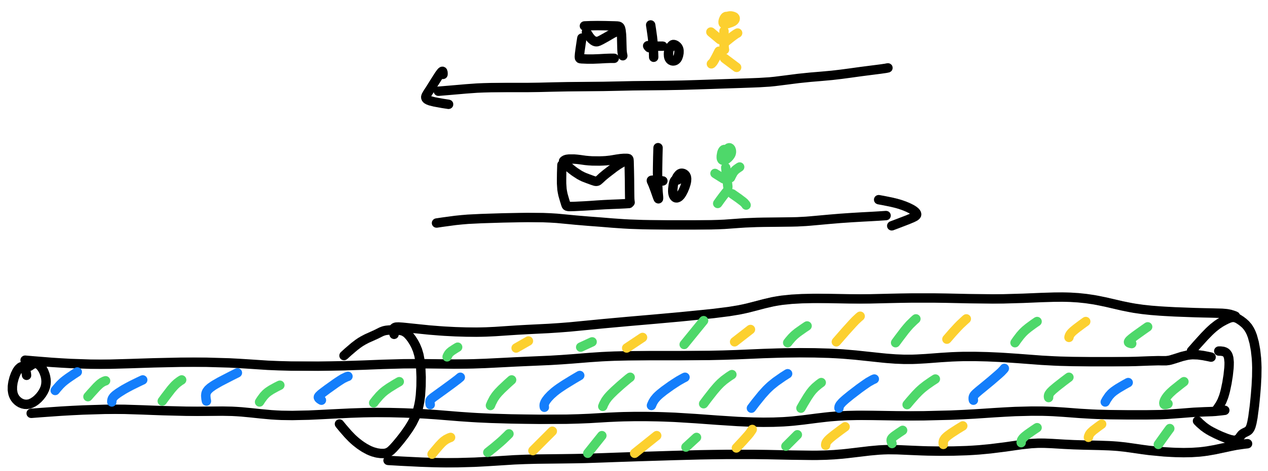




Nested Double Ratchet

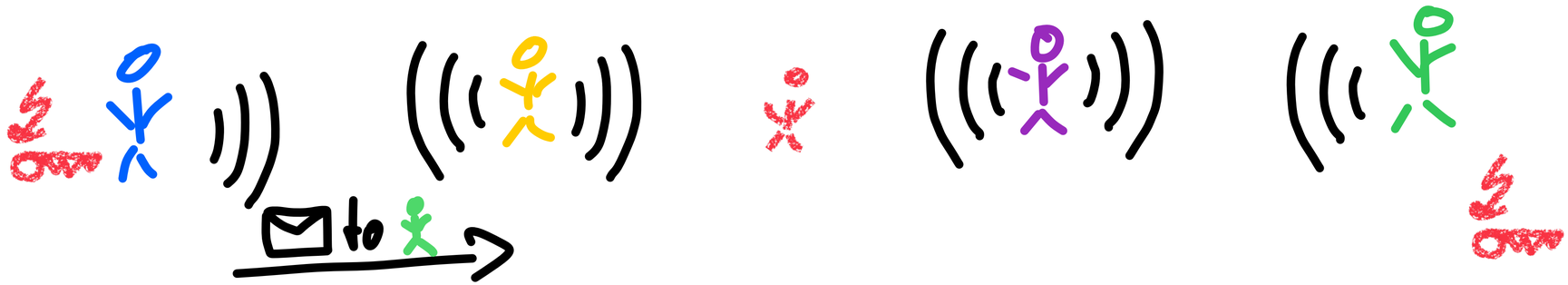
Mesh Networks: Construction

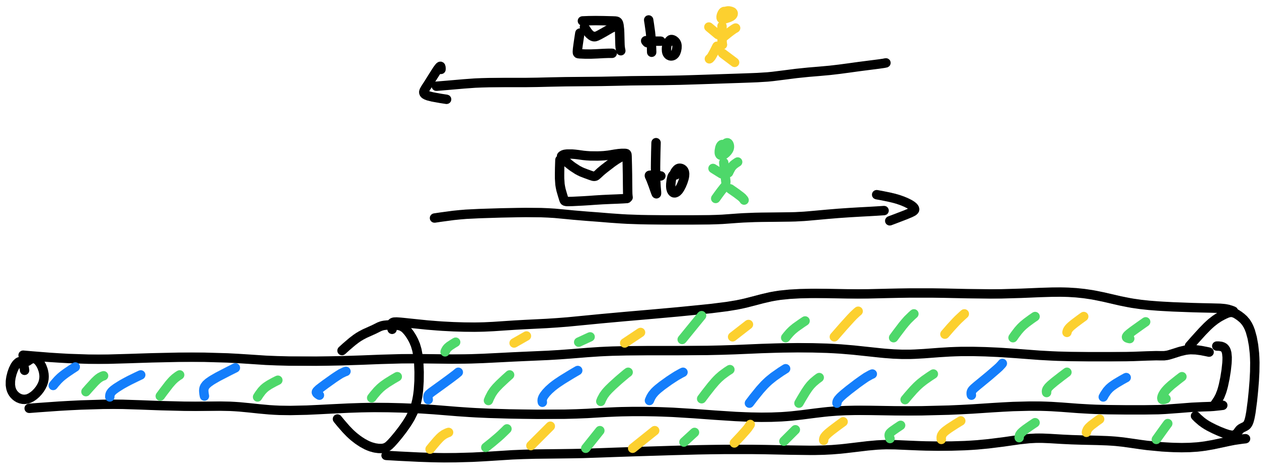




Nested Double Ratchet

Mesh Networks: Construction

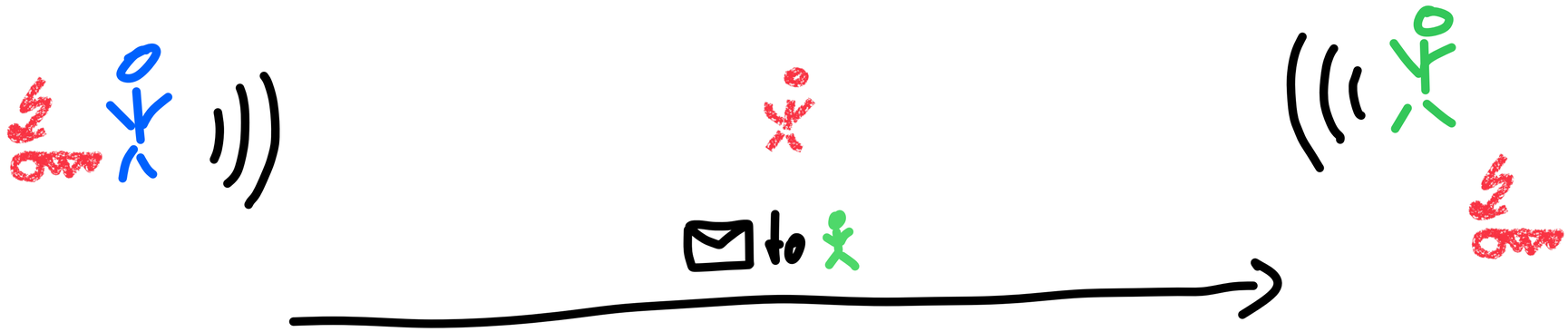




Nested Double Ratchet

+ PKE for every message
+ New pk DH every message
+ ...
⇒ Strong (ish) FS & PCS

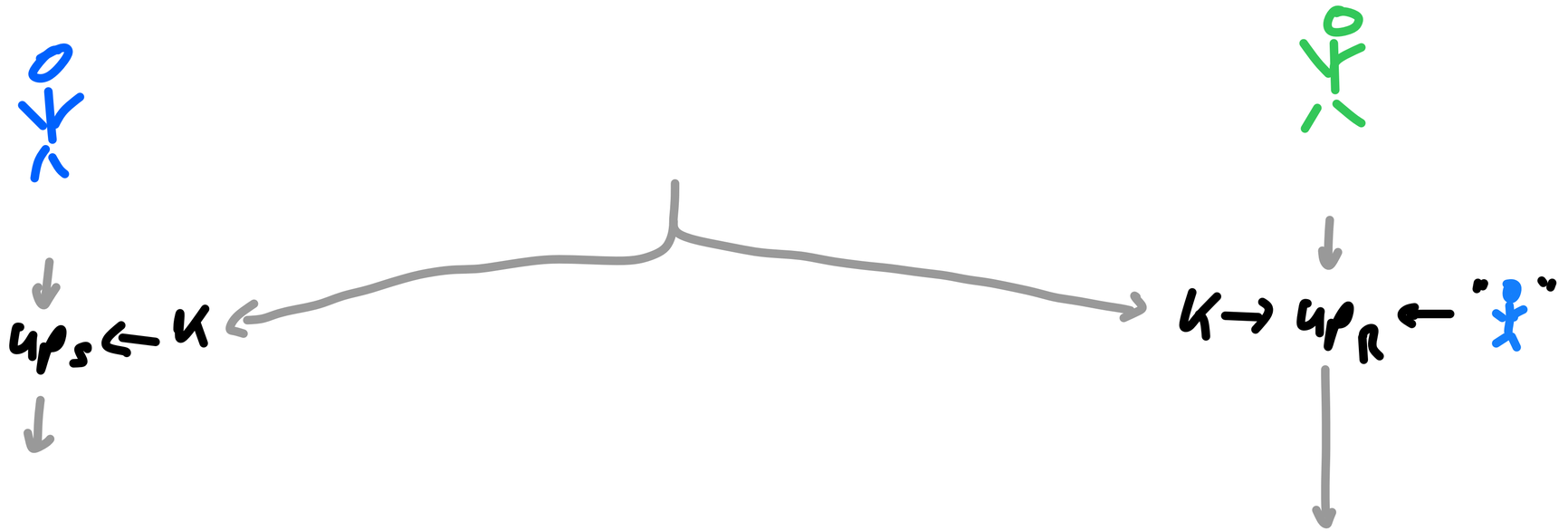
Anonymity: Related Work



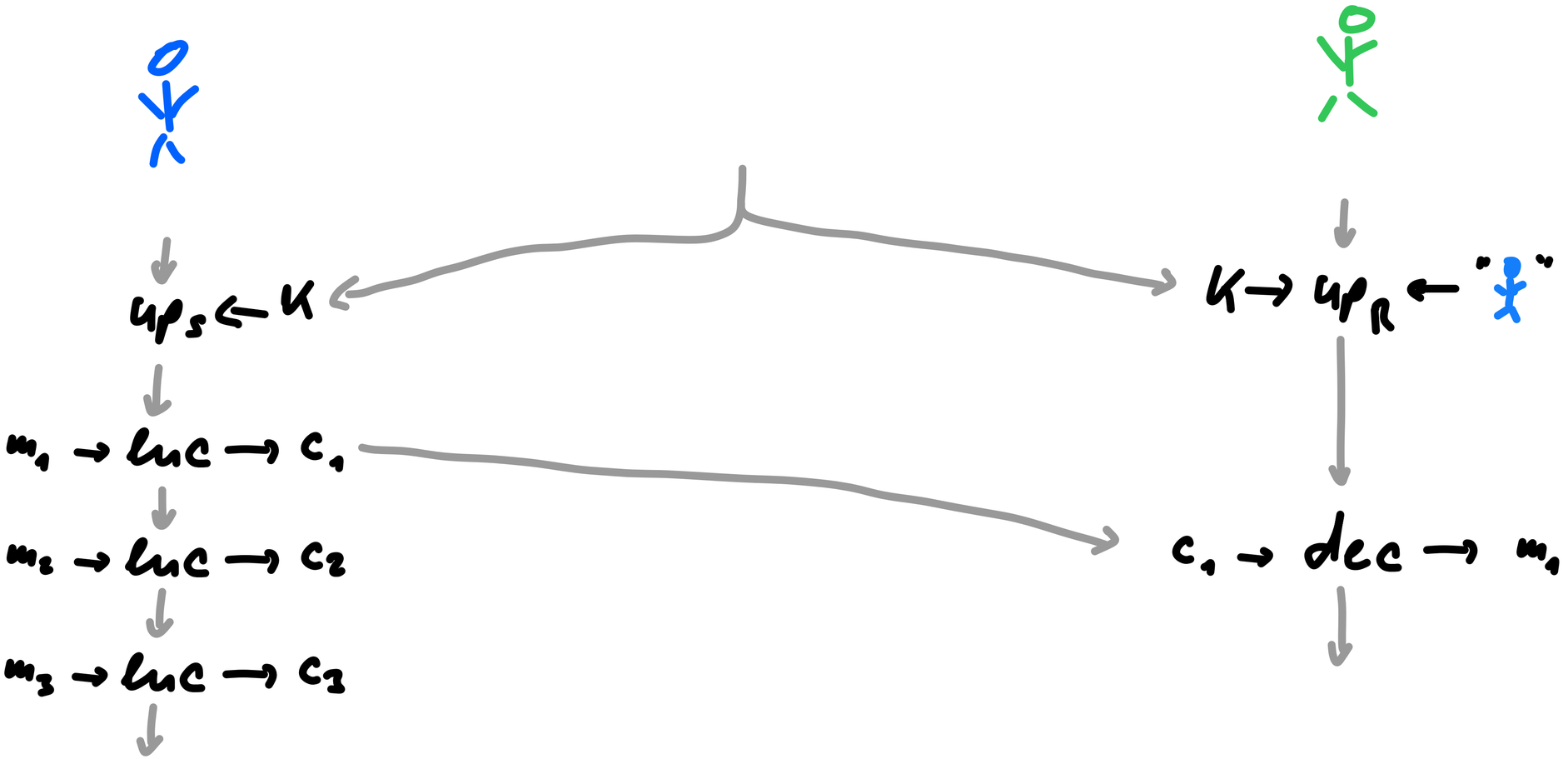
- Double Ratchet: Re-send g^a + Counters ⇒ No Anon
- Sealed Sender: PKE to static Key ⇒ No FS / PCS
- DHRR'22: Unidirectional reliable communication ⇒ unsuitable for mesh networks

Anonymity: Message Anonymizer Syntax

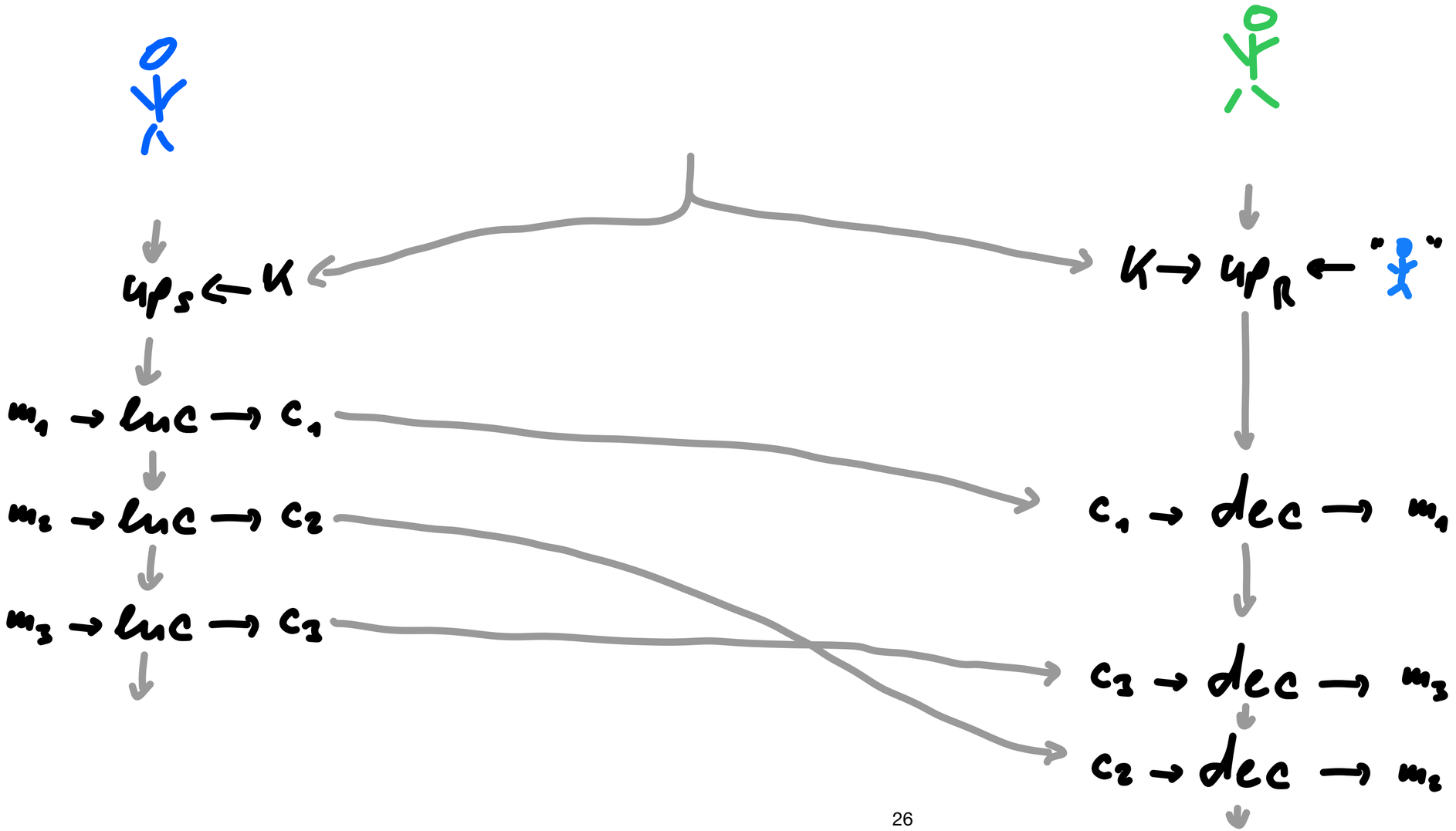
Anonymity: Message Anonymizer



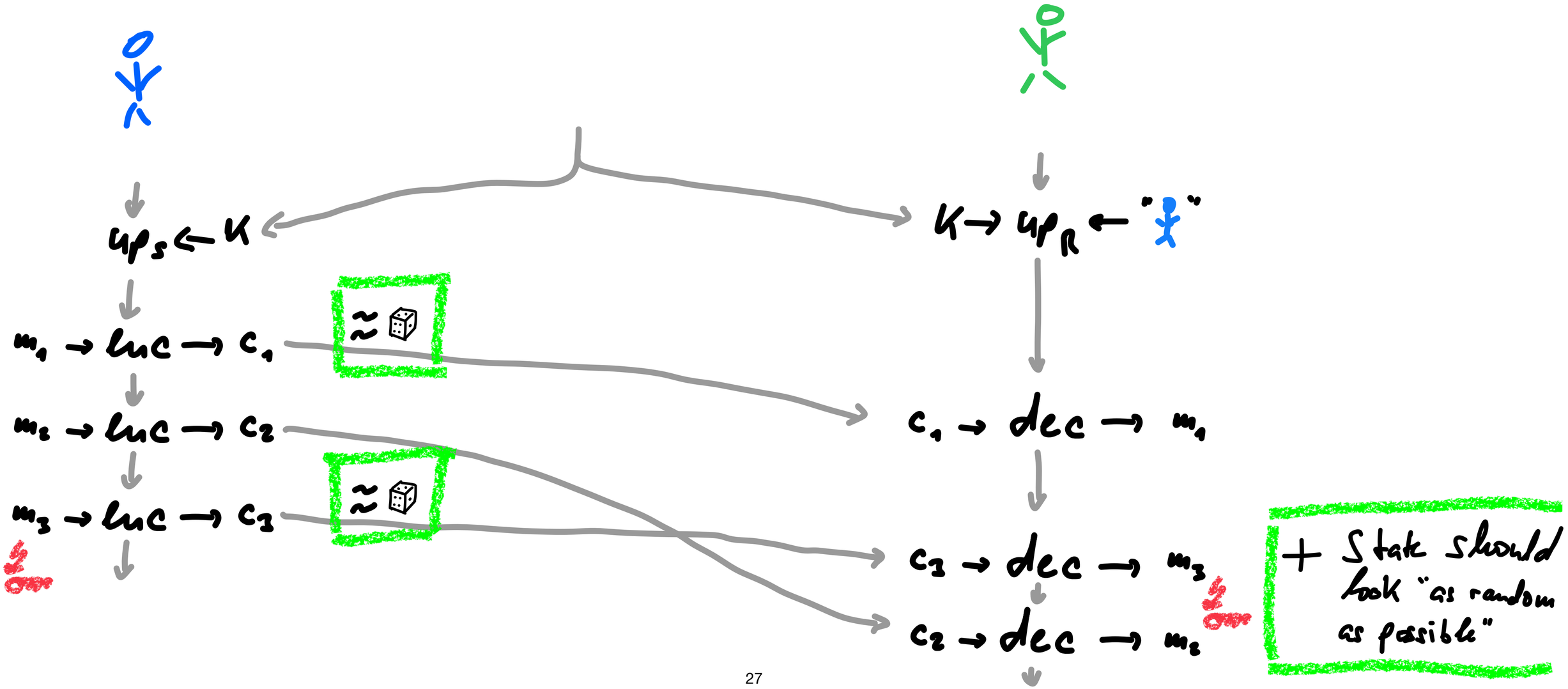
Anonymity: Message Anonymizer



Anonymity: Message Anonymizer



Anonymity: Message Anonymizer Security



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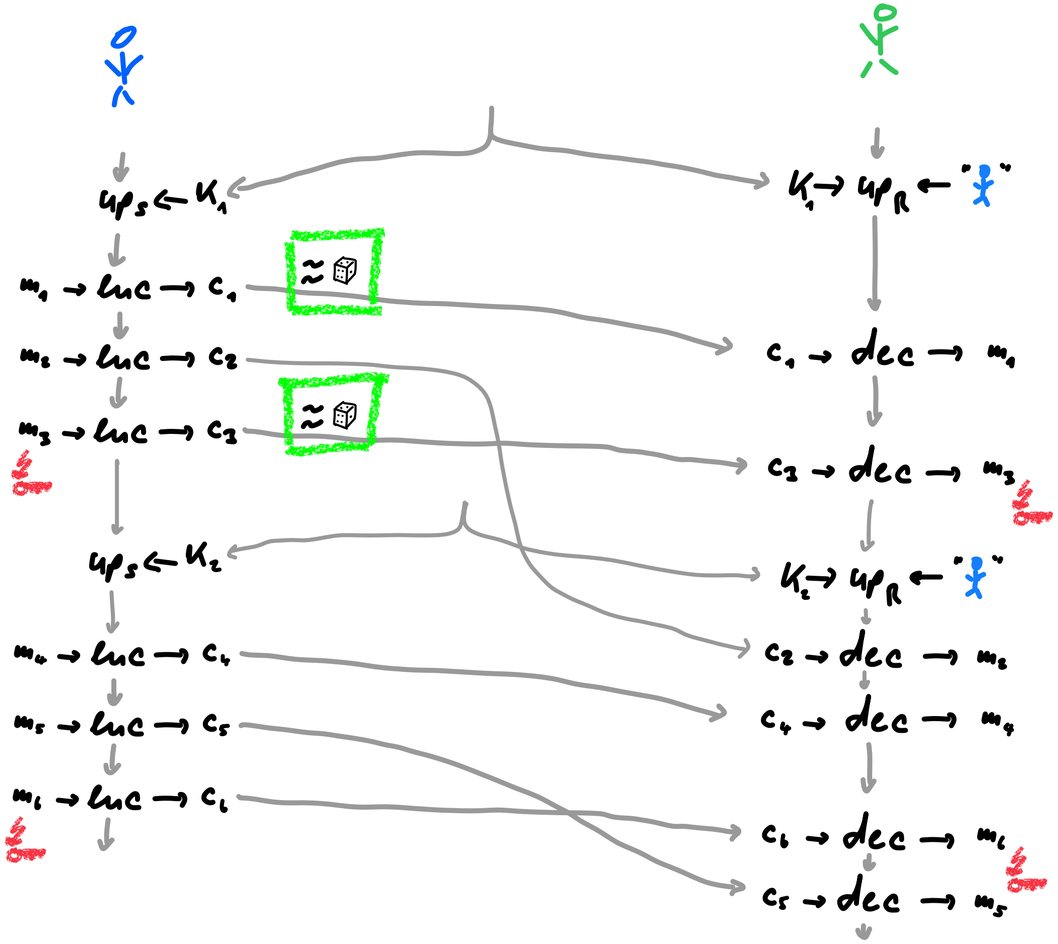

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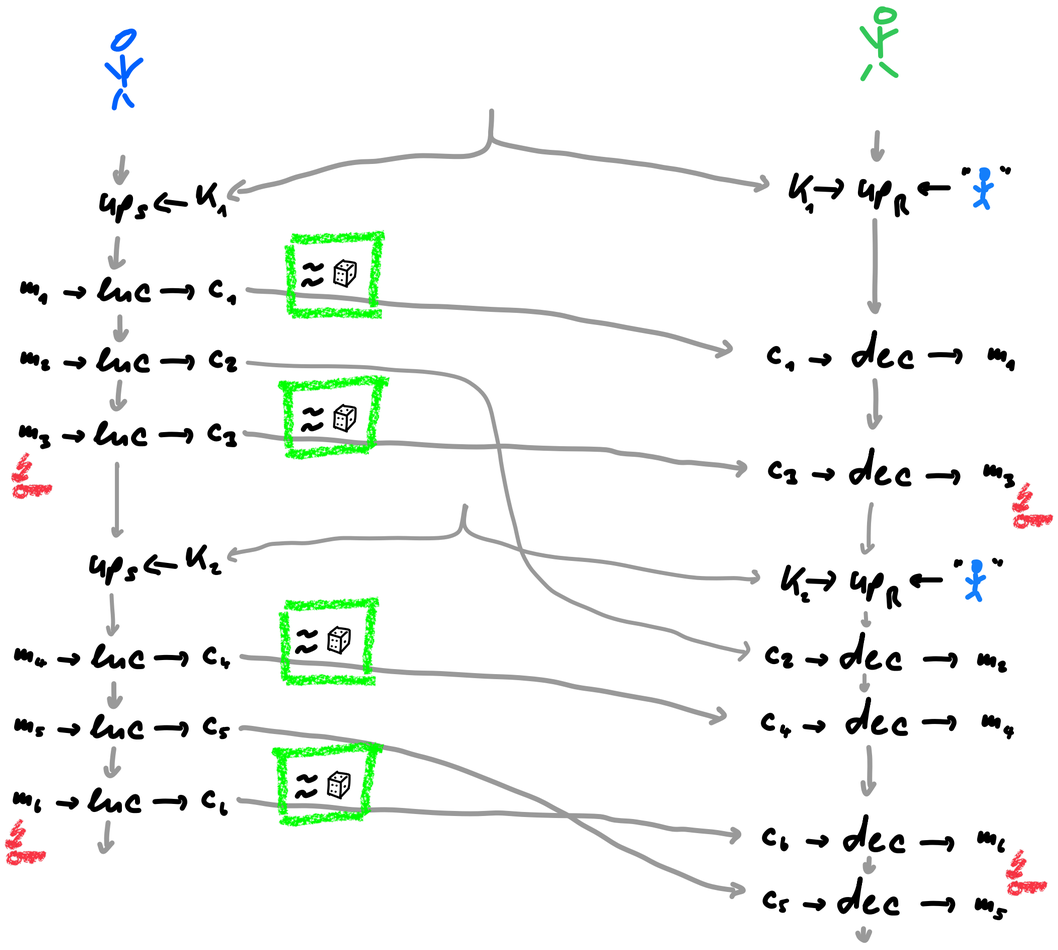
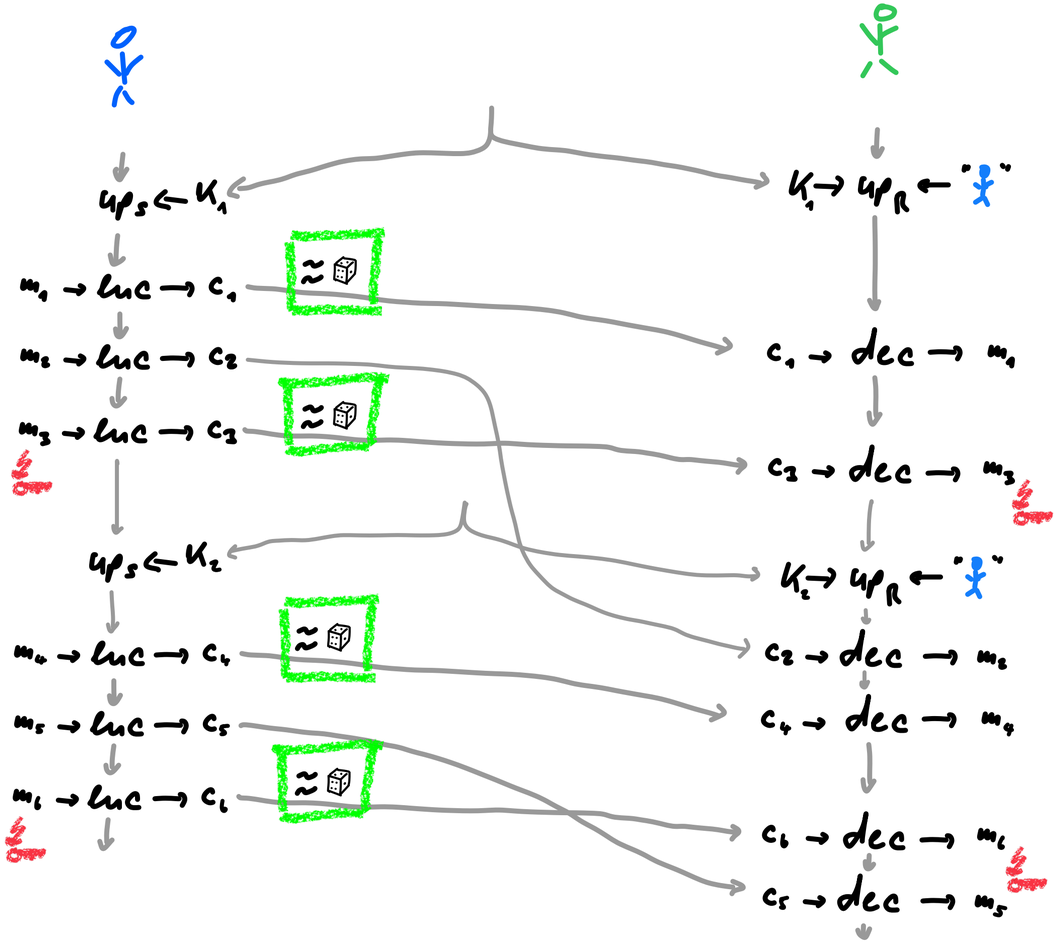
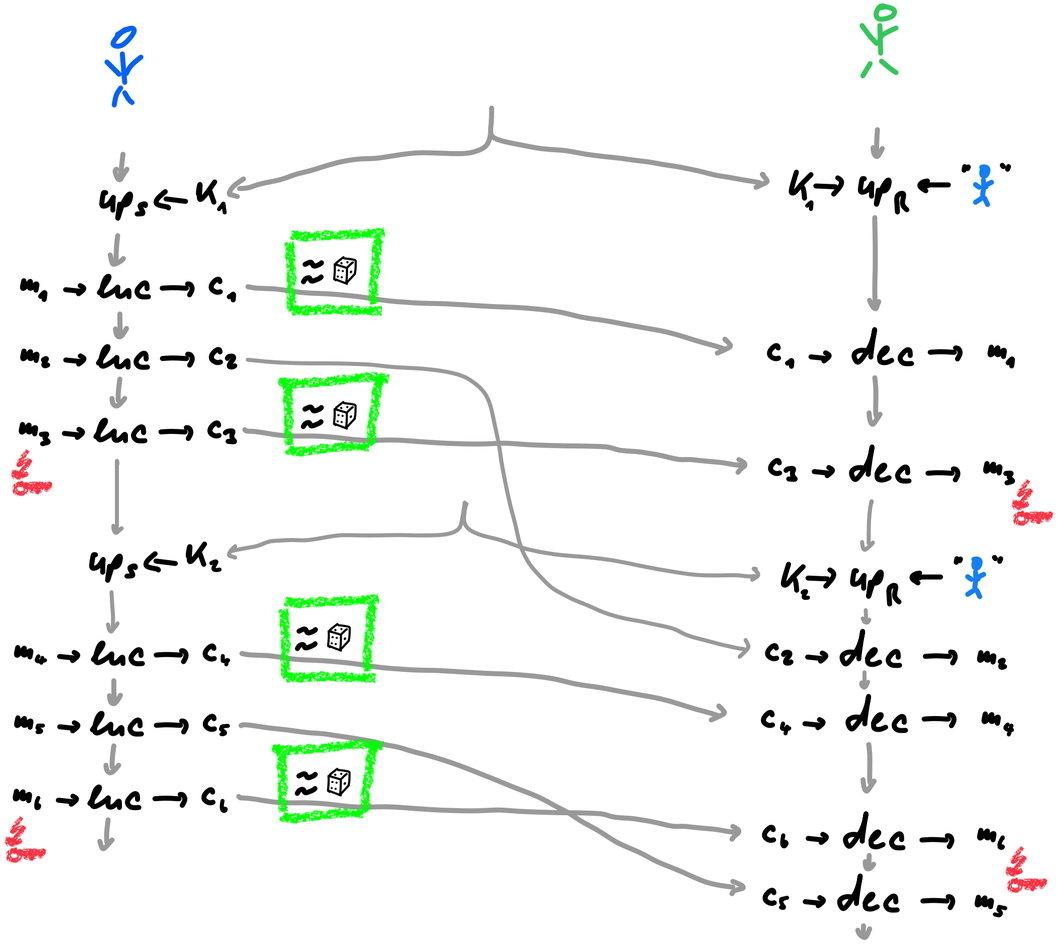


Anonymity: Message Anonymizer

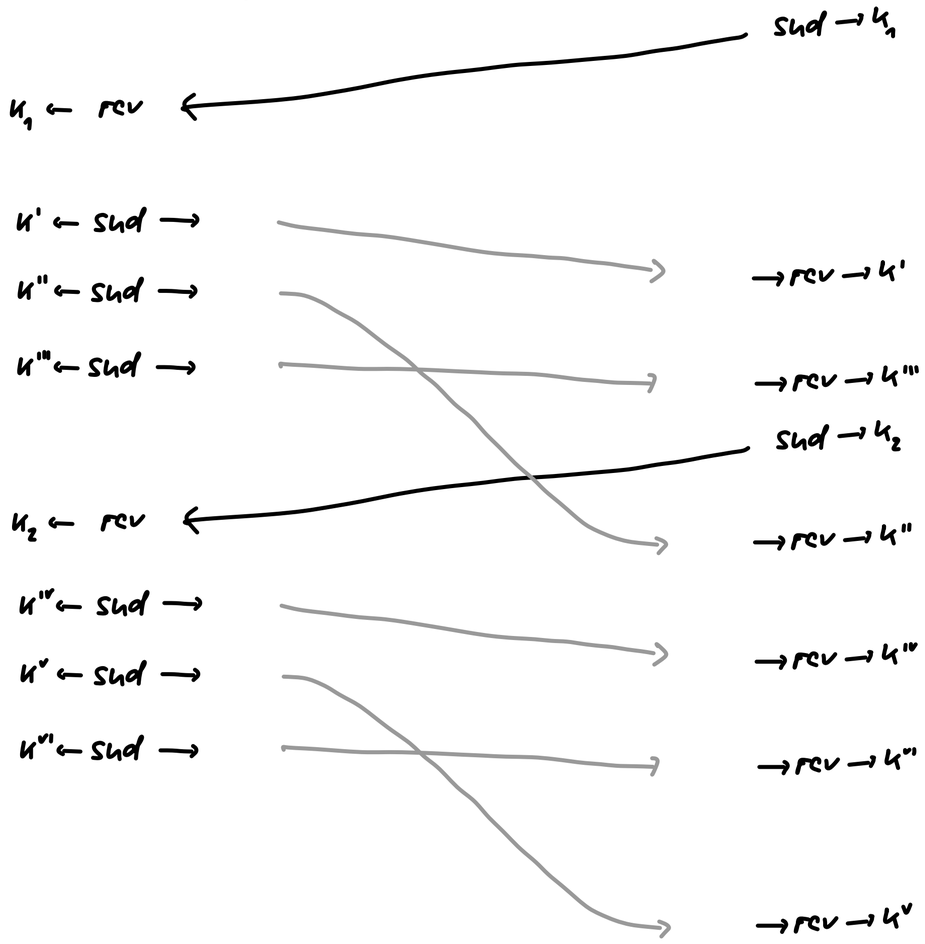
Composition w/ DR



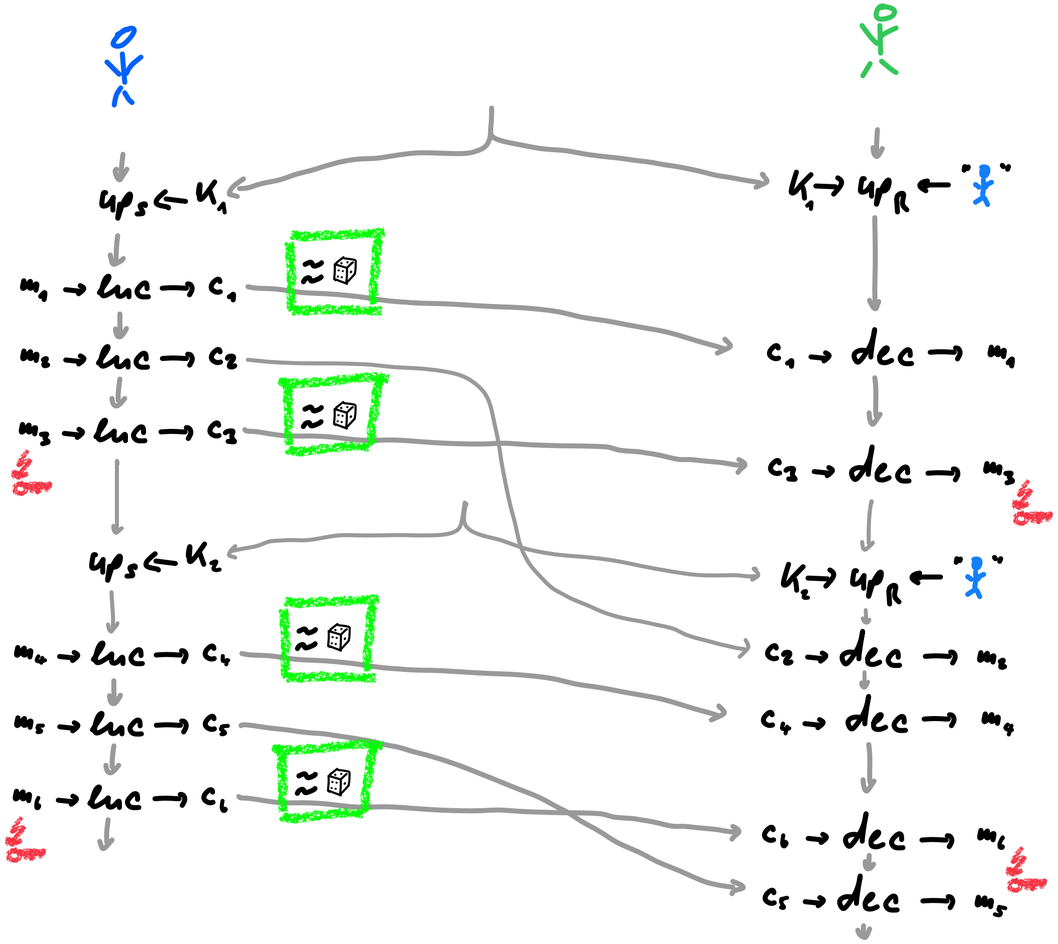
Anonymity: Message Anonymizer



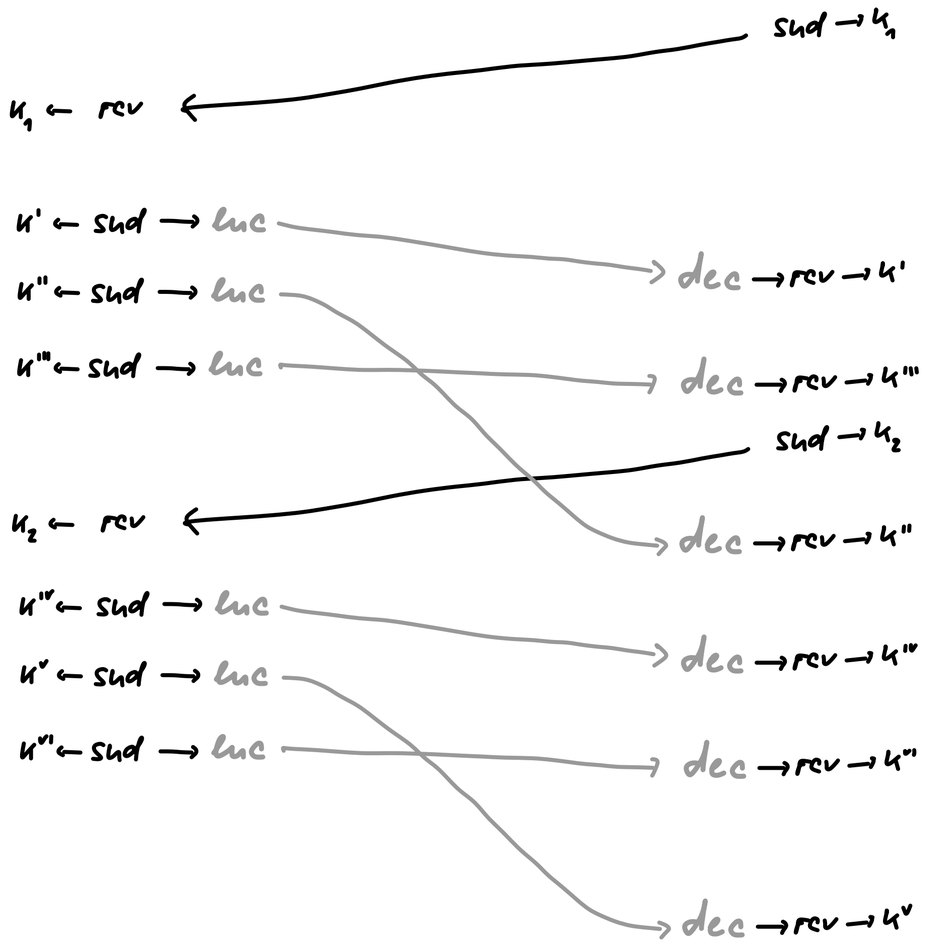
Composition w/ DR



Anonymity: Message Anonymizer



Composition w/ DR



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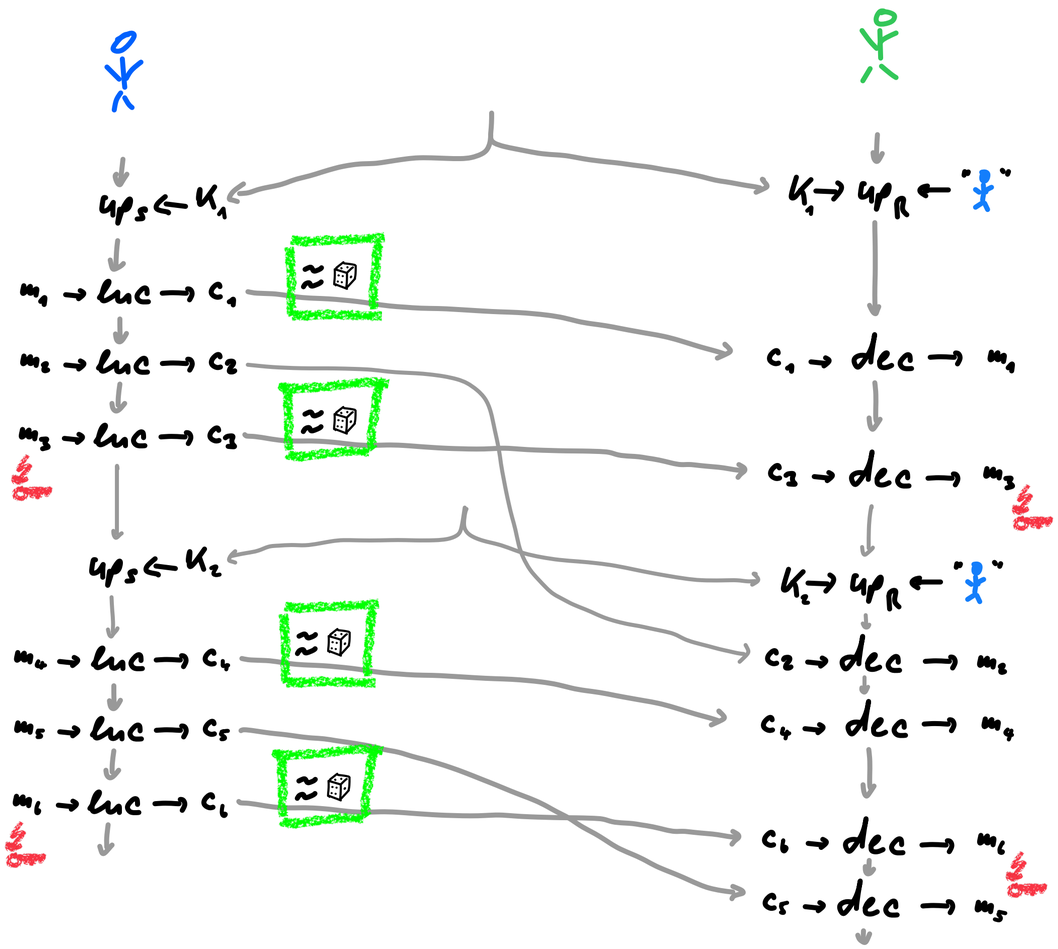
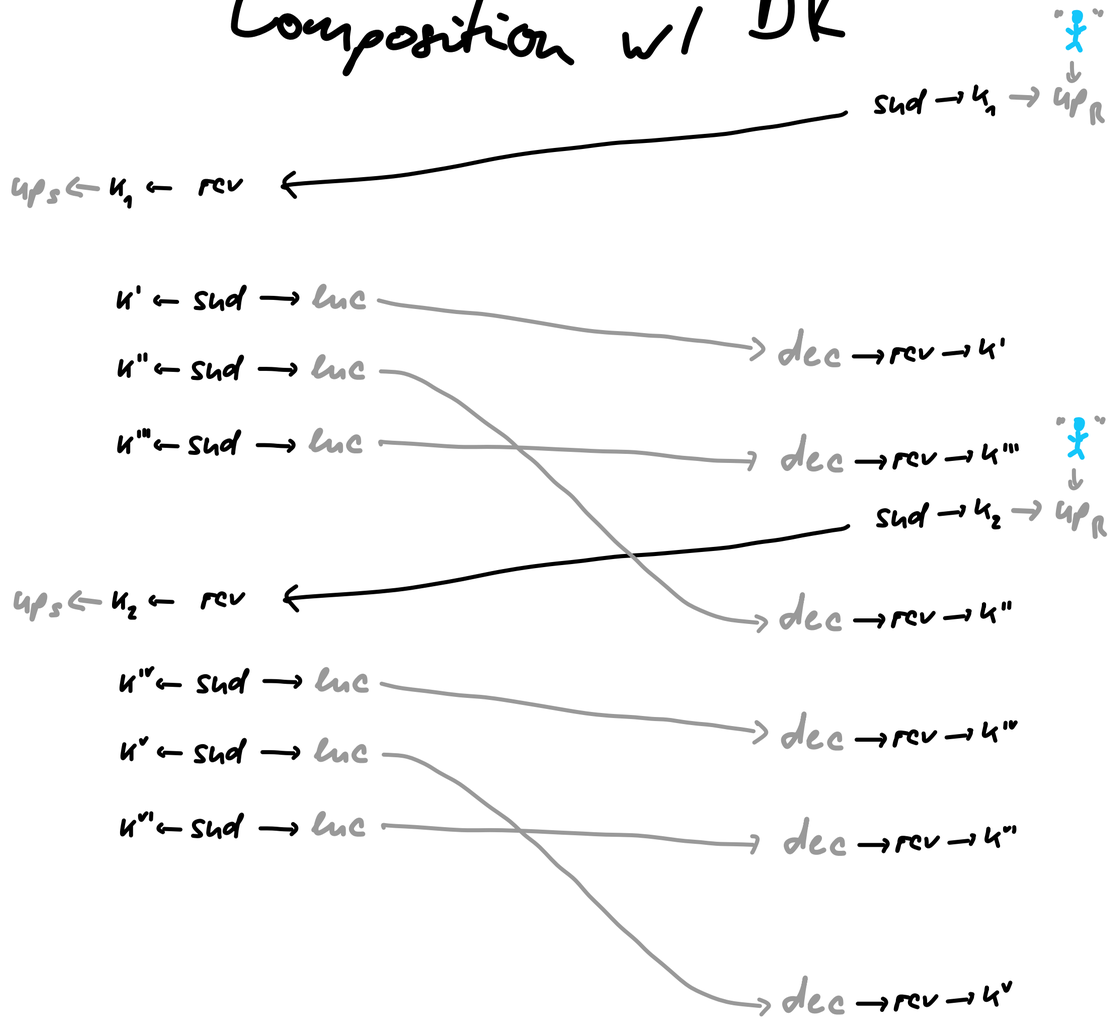
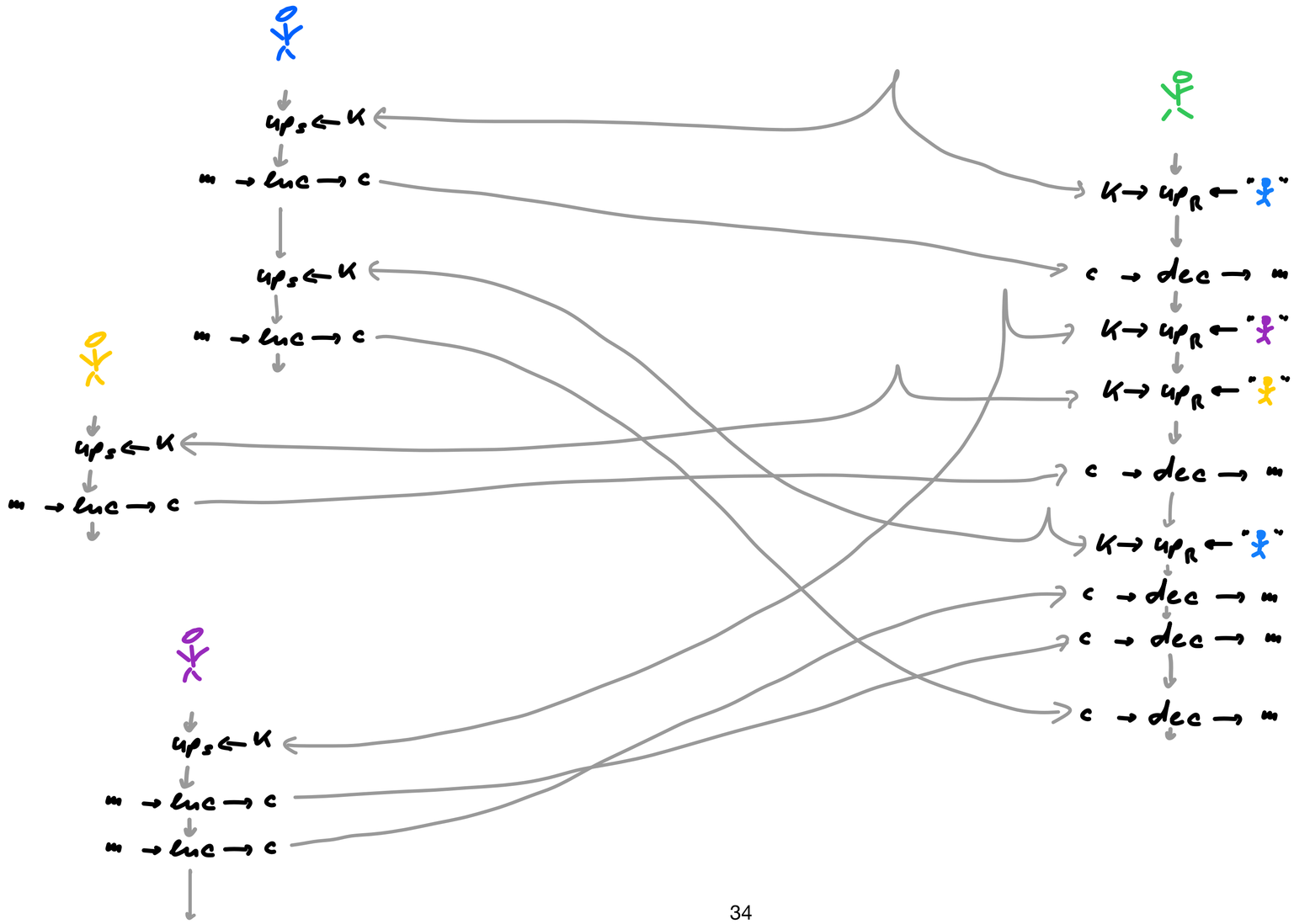


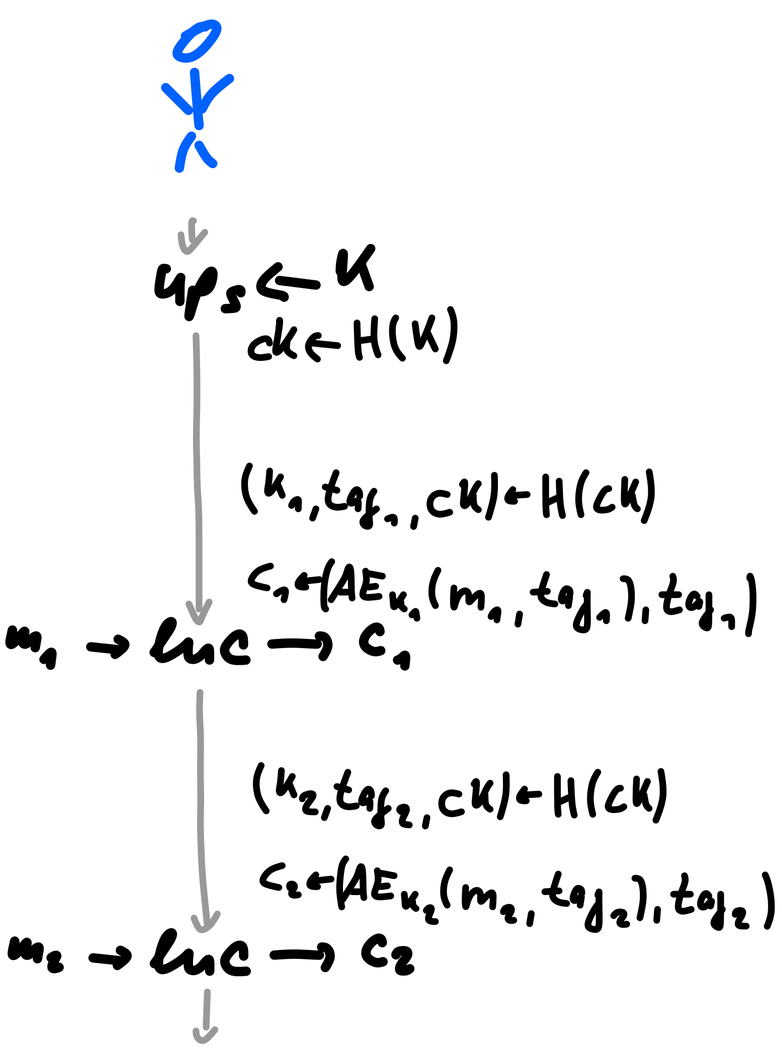
Composition w/ DR

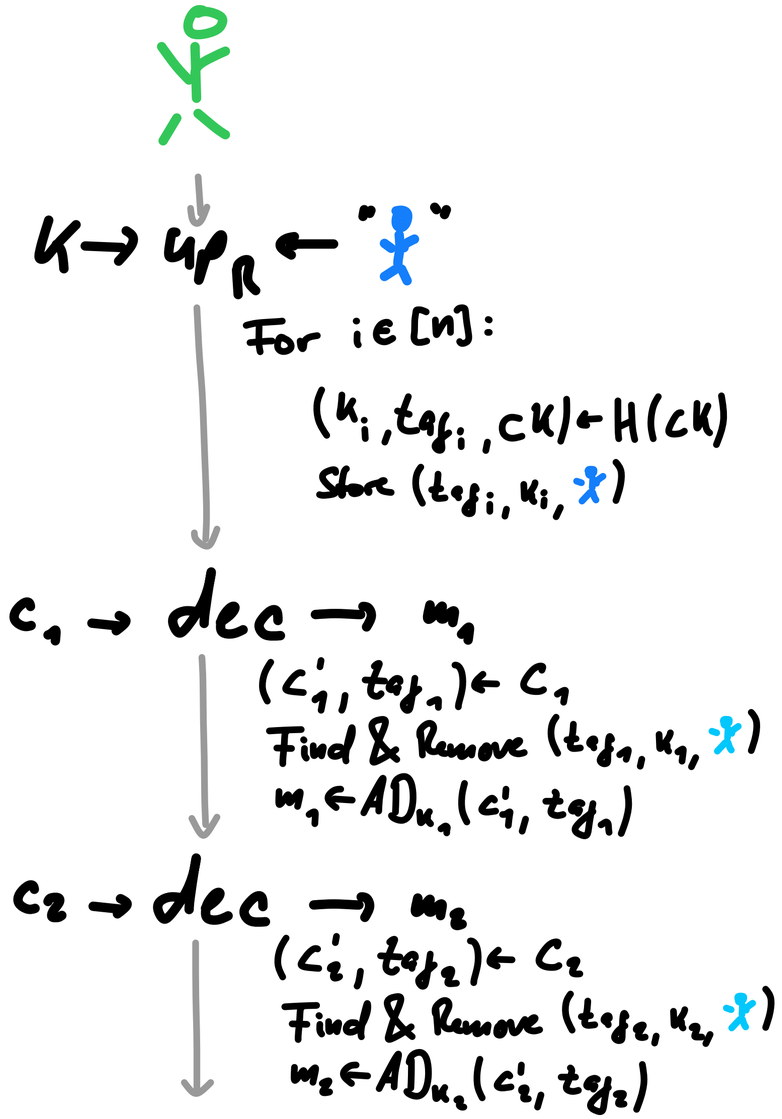


Anonymity: Message Anonymizer Multi Sender



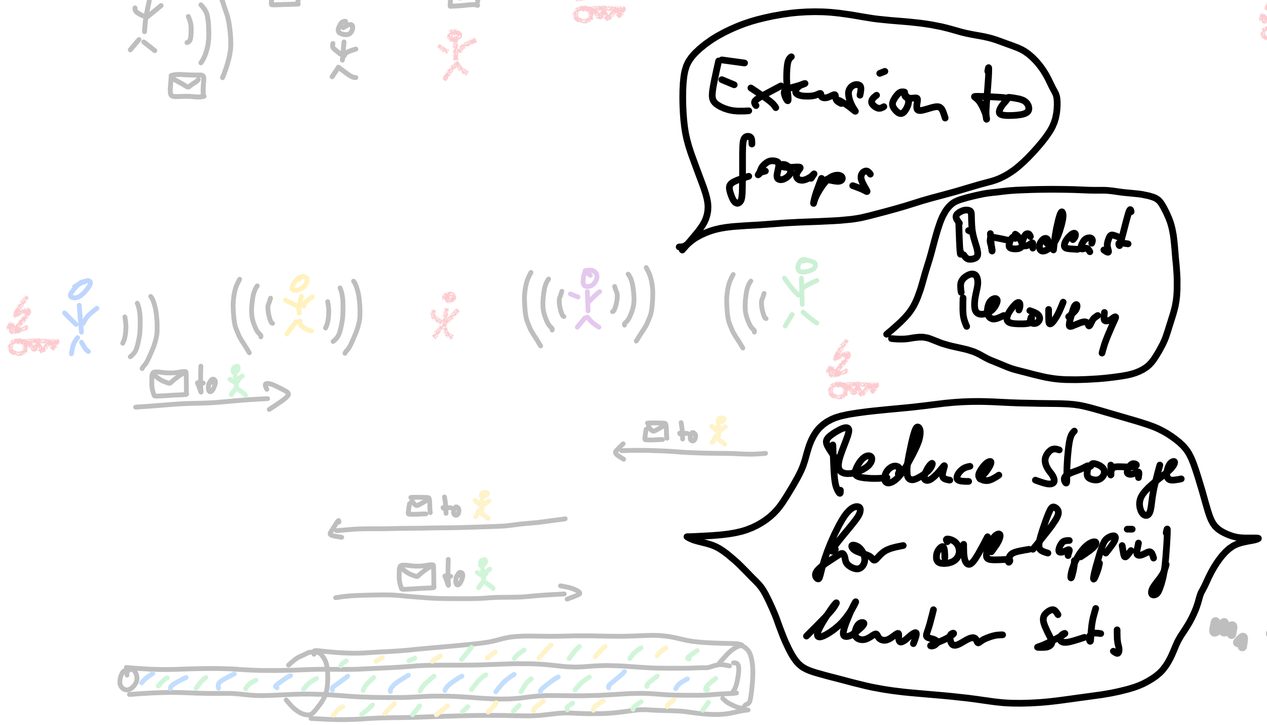
Anonymity: Message Anonymizer Construction

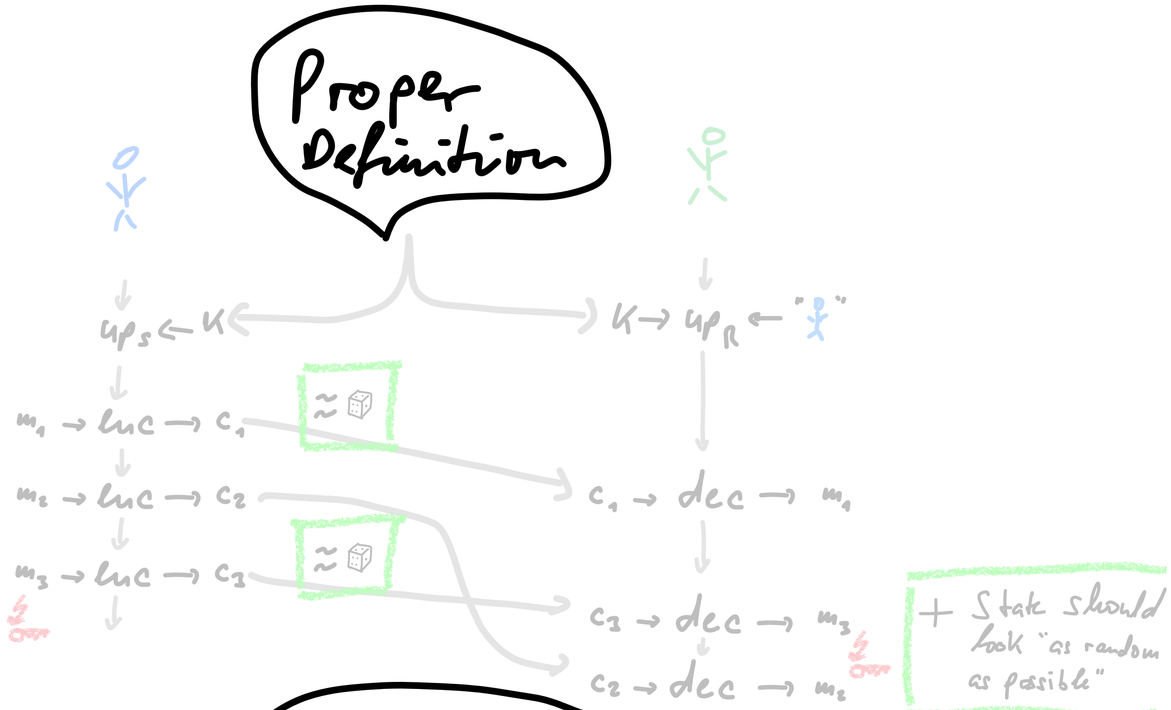


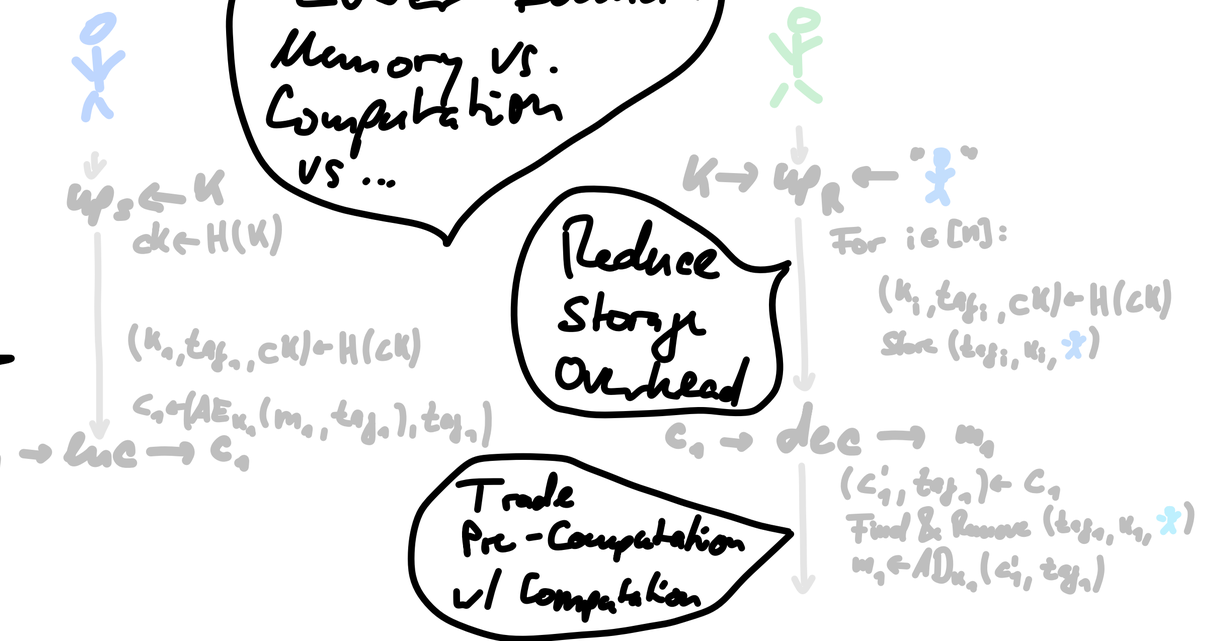


Summary


Censorship

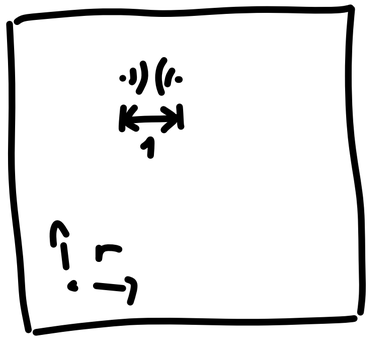

Extension to groups
Broadcast Recovery
Reduce storage for overlapping Membership Sets
to
to
to
to


Proper Definition
+ State should look "as random as possible"


Lower Bound: Memory vs. Computation vs...
Reduce Storage Overhead
Trade Pre-Computation w/ Computation

Simulation & Evaluation

$A \times A = 25^2$ Field



max Node Degree

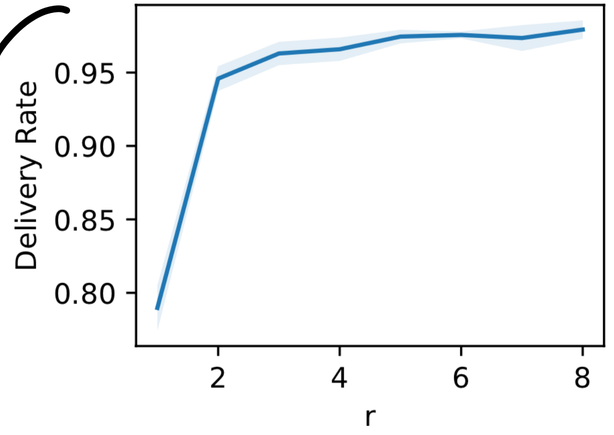
max Path Length

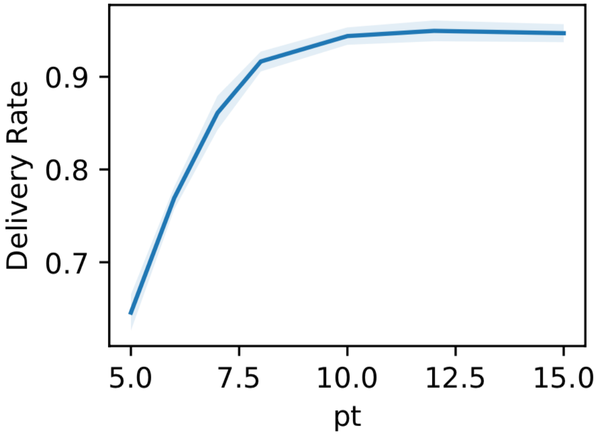
Distance/Step

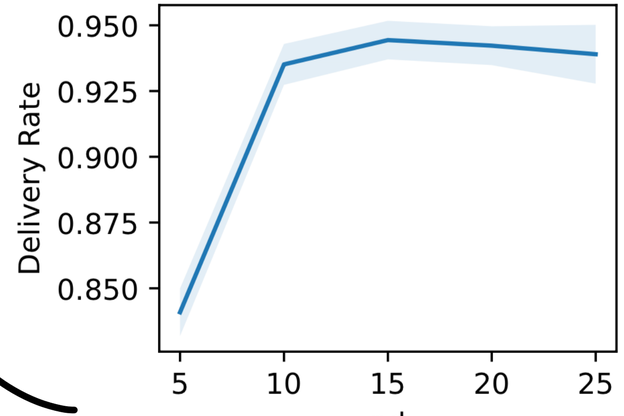
Users

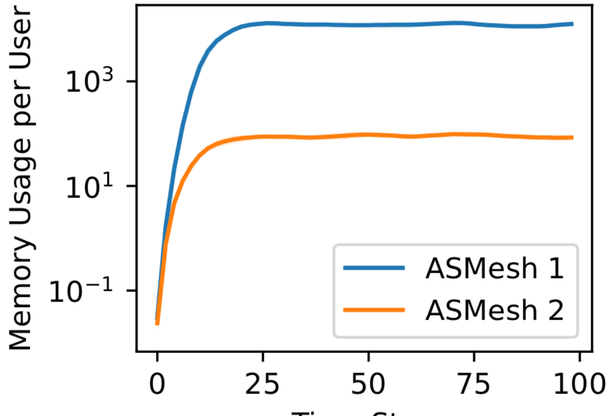
Profile	n	r	pt	nd	#Hops	Latency	#Re-enc
Standard	600	2	10	25	5.355	5.983	0.503
					5.396	6.043	n/a
Dense	3000	10	5	5	4.550	4.550	0.372
					4.545	4.545	n/a
Sparse	100	10	10	20	3.356	5.699	0.301
					3.367	5.490	n/a

Delivery Rate > 90%







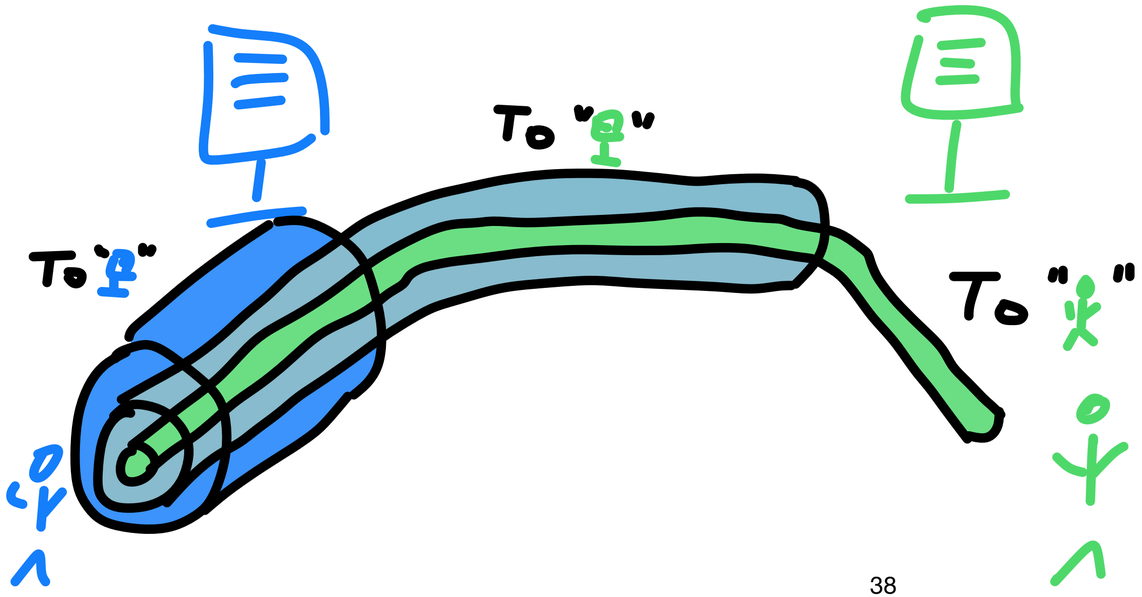


Anonymity : Broader Context

Hides Social Graph

↳ Used by Signal

↳ Relevant to Interoperable Messaging (GDPR + DMA)



Lower Bound

Simplest Syntax

$(sk_1, \ldots, sk_n, rk) \leftarrow gen$

$(sk, c) \leftarrow enc(sk, m)$

$(rk, m) \leftarrow dec(rk, c)$

1) if $|rk| = n \cdot m$, then 1

Simplest Execution Model

Snd(i, m, ch) -> c : c is random if ch=b=1

Rcv(c)

SCorrupt(i) -> sk_i // w/o: global symm. key

RCorrupt -> rk // w/o: global pub. key

↳ should "look random": hide # ctxts/sender

// w/o: puncturable symm. enc (tree)

// w/: if pre-computed symm. keys in rk