BlindHub: Bitcoin-Compatible Privacy-Preserving Payment Channel Hubs Supporting Variable Amounts

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MONASH University

Radboud Universiteit

TU Delft Delft University of Technology

Outline

- Introduction

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- Introduction
  - Private payments

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    - Private payments on Bitcoin Network

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  - Our solutions

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- Future

Payments

Private Payments

Private Payments

Bitcoin !

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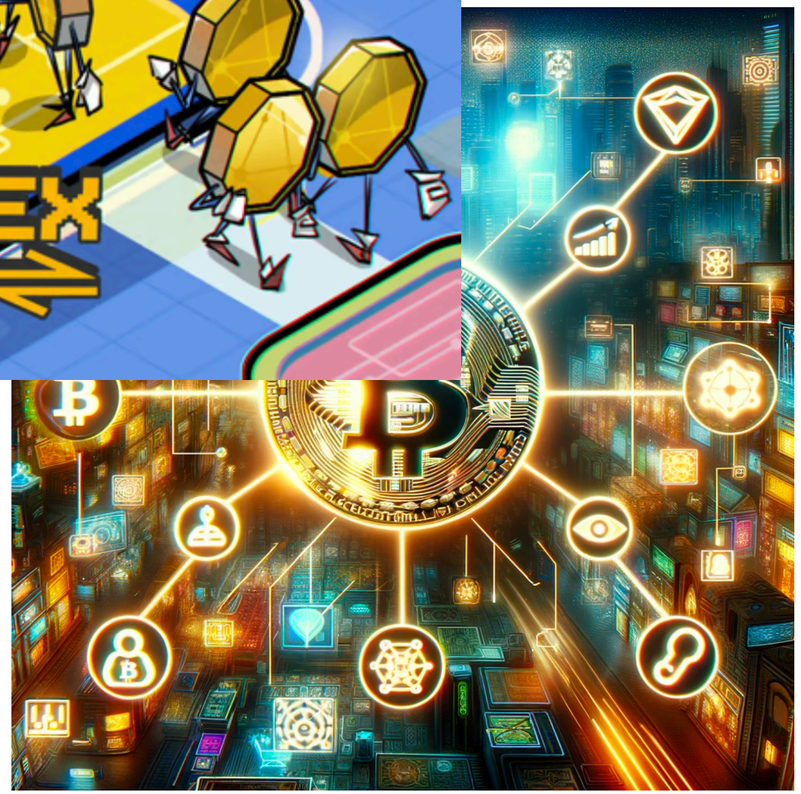

Bitcoin:
To The Moon!

Congestion…

Scaling Bitcoin

Scaling Bitcoin

Payment Channel
(Lghtning Network)

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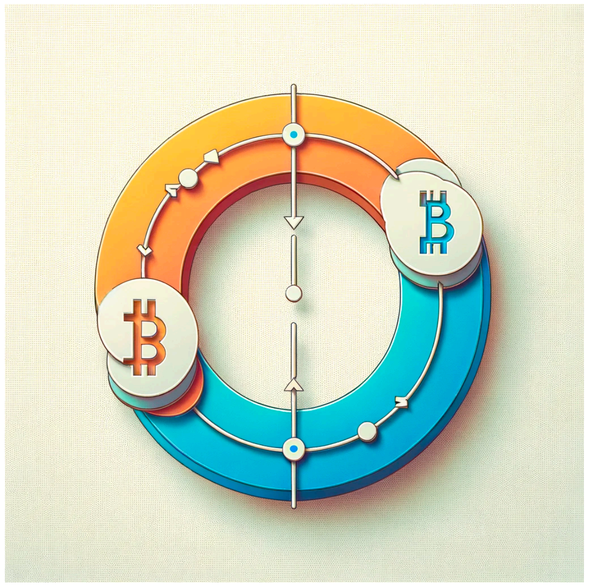
(Lghtning Network)



Side Chain
(Liquid Network)

Scaling Bitcoin

Payment Channel
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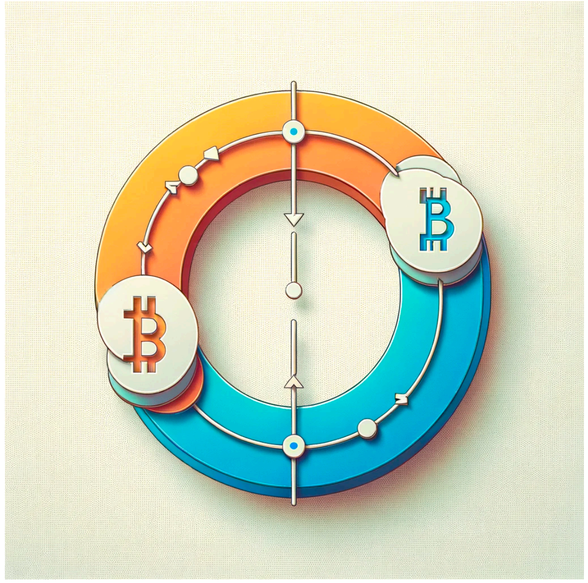

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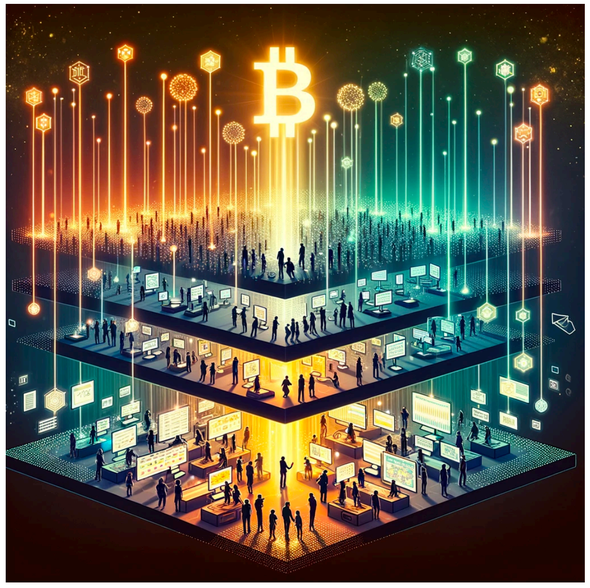

RGB, BitVM,
Bitcoin Rollup…

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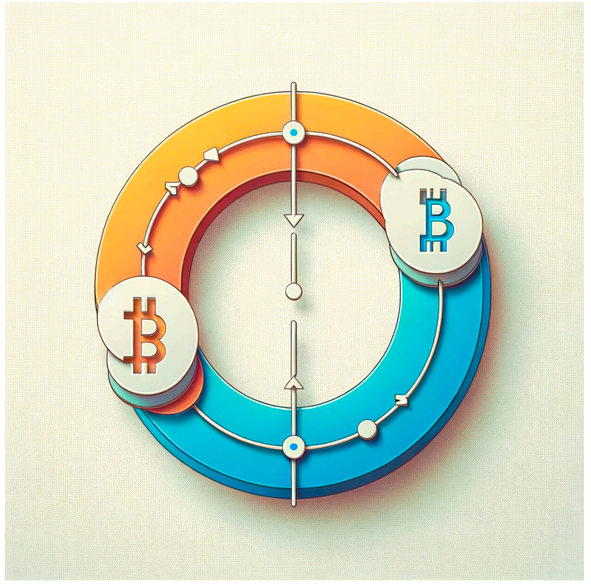

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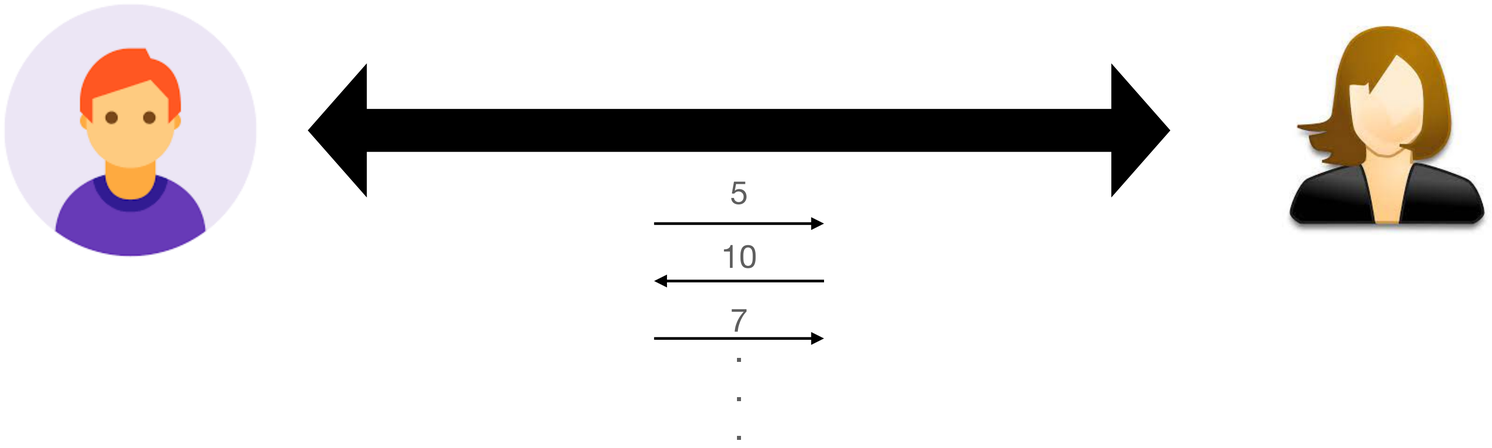
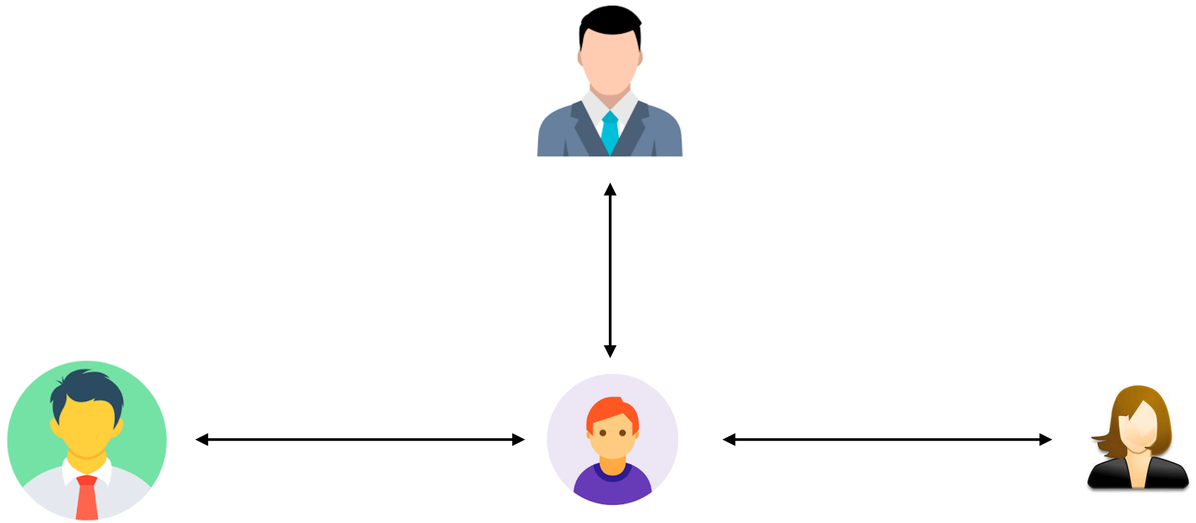
Payment Channel

- Payment channel is regarded as one of the most promising solutions for addressing scalability problem
  - Payment channels allow for unlimited off-chain payments, with only the channel's opening and closing recorded on the blockchain

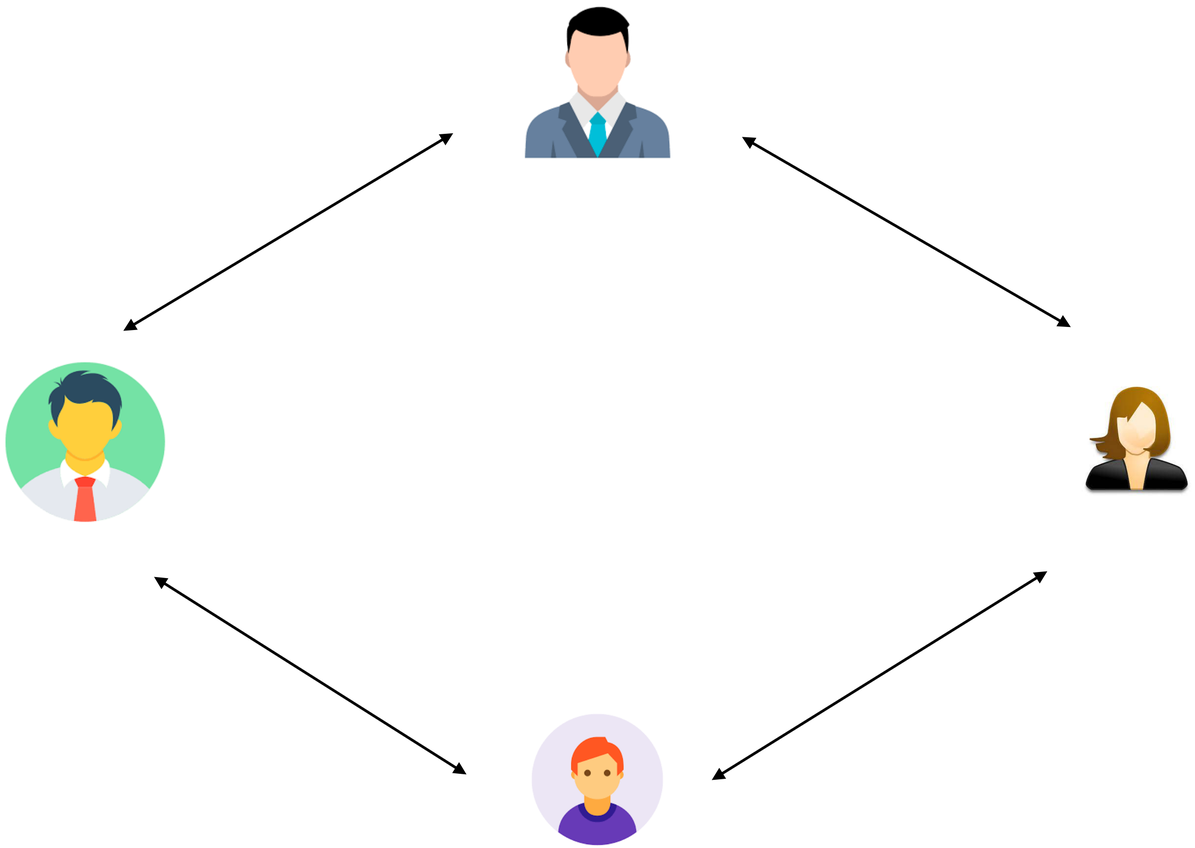


Payment Channel

- Payment channel is regarded as one of the most promising solutions for addressing scalability problem
  - Payment channels allow for unlimited off-chain payments, with only the channel's opening and closing recorded on the blockchain
  - Financially infeasible to build channel with everyone



Payment Channel Network



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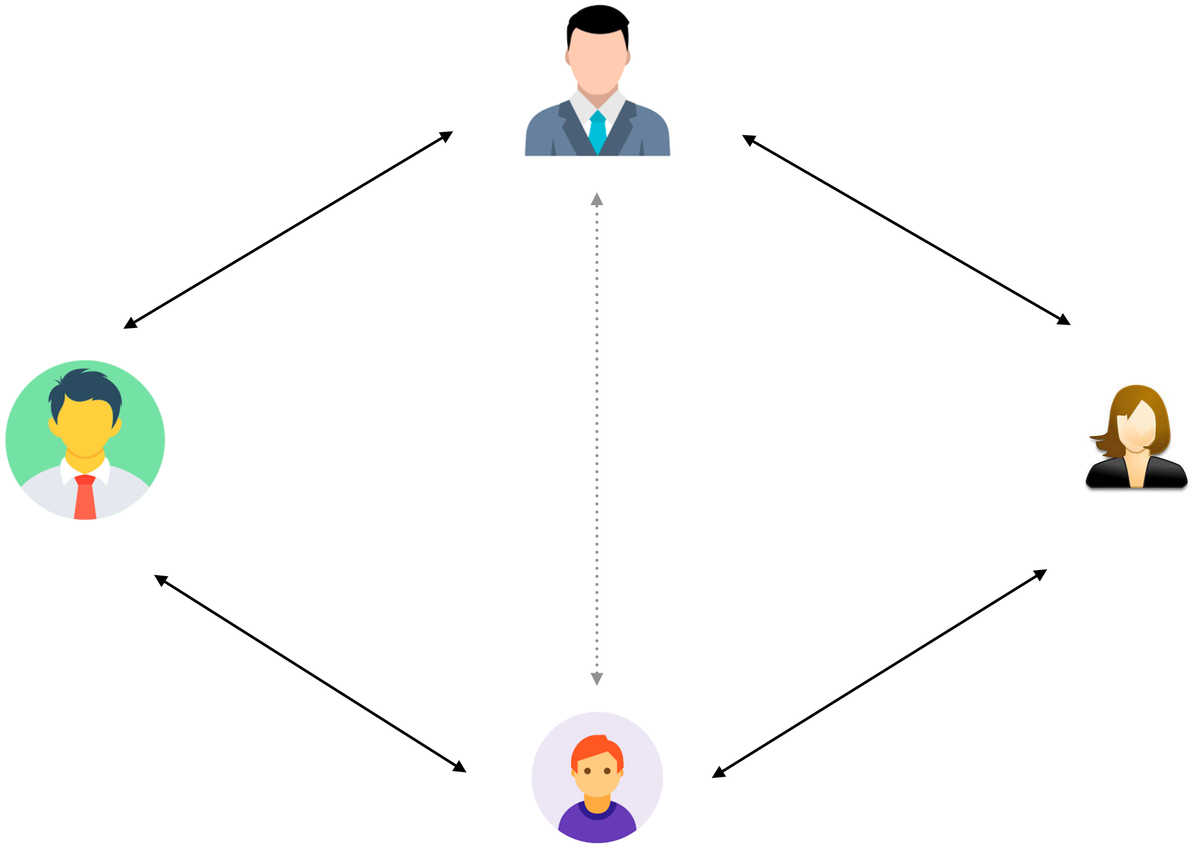

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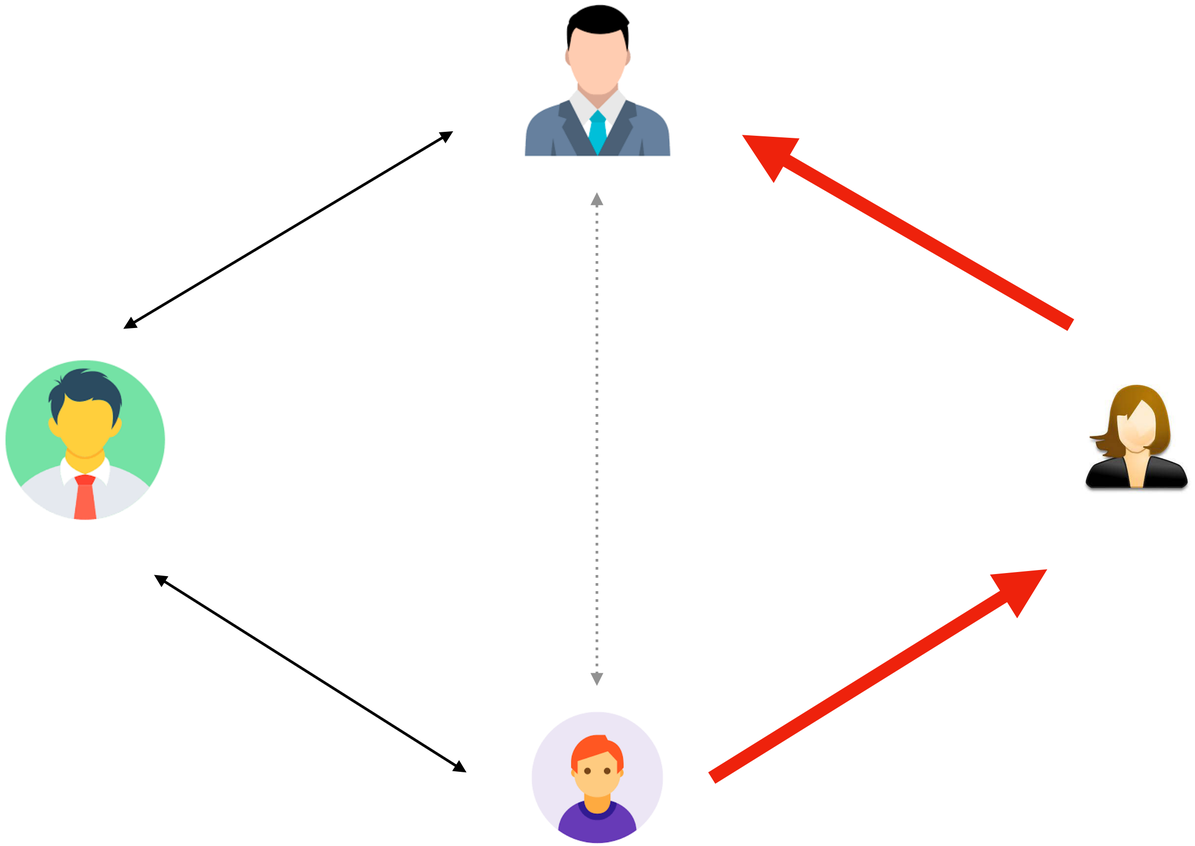
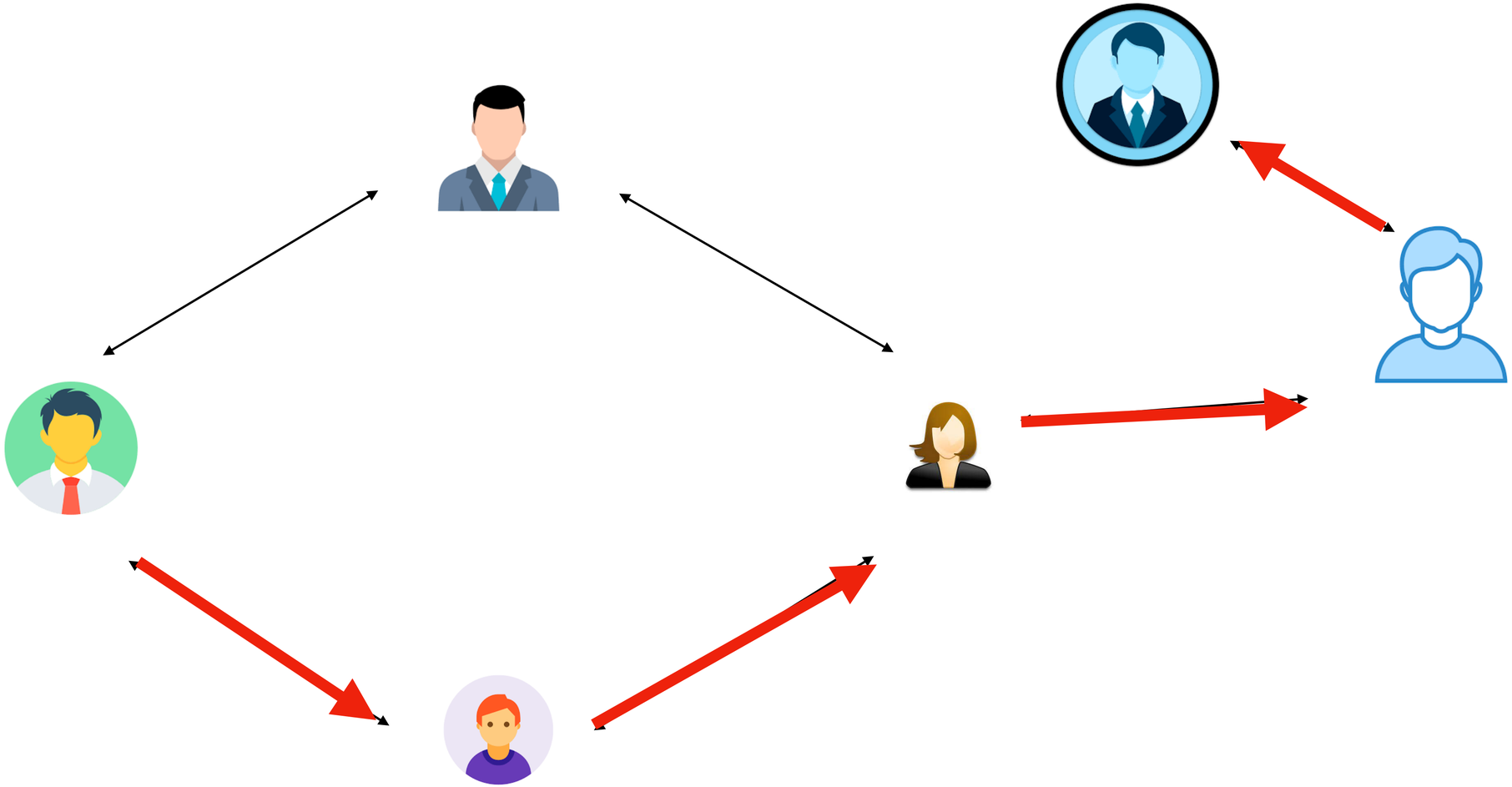
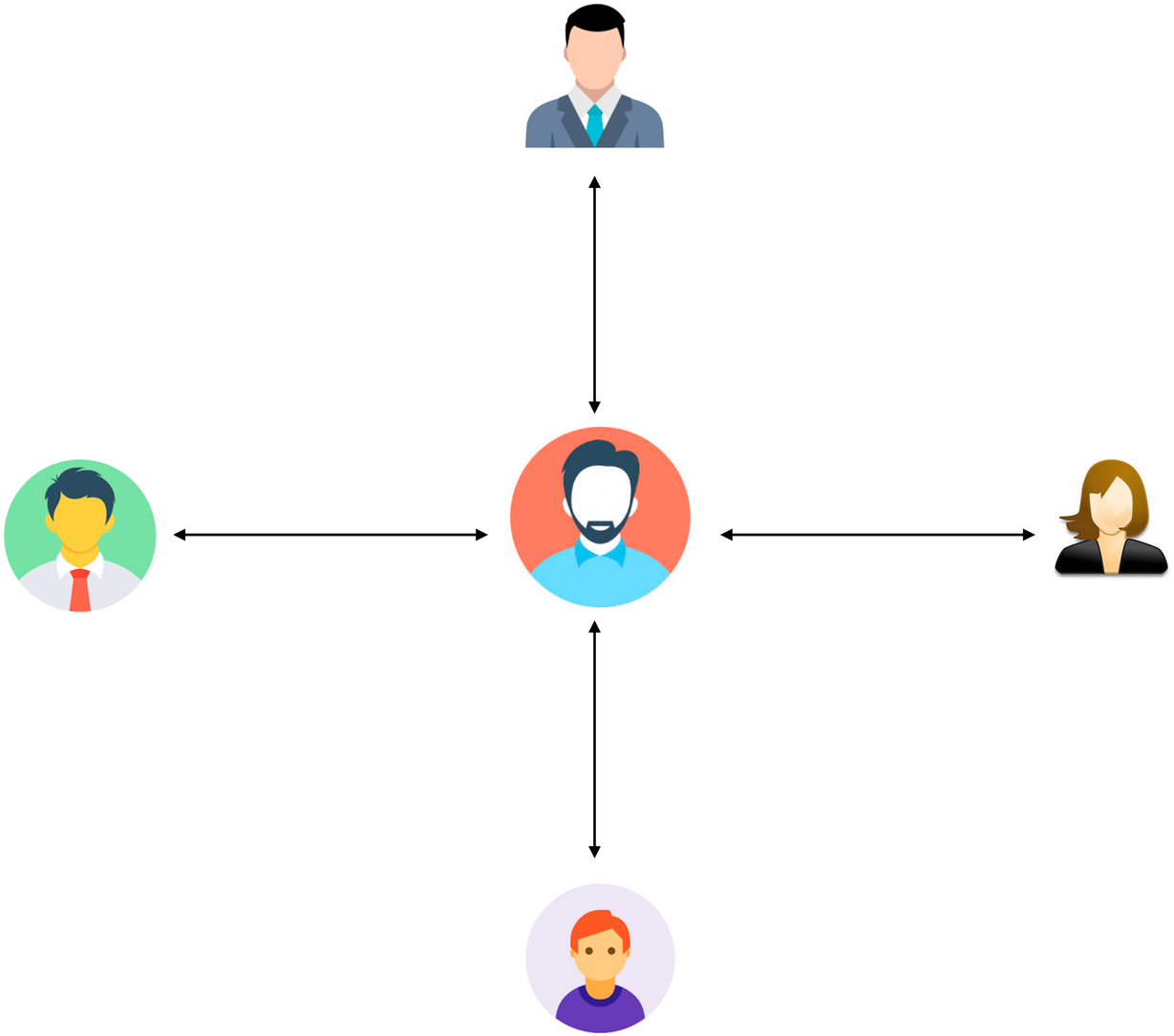


Payment Channel Network

- Require routing, active participation of parties

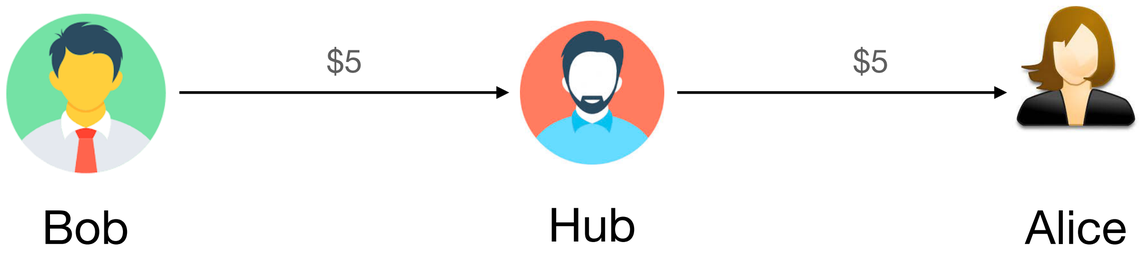


Payment Channel Hub

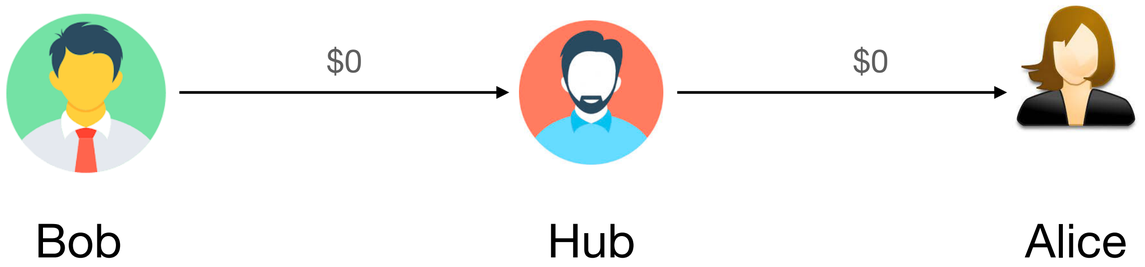


Payment Channel Hub

- Atomicity: Either Alice receives m coins from hub and hub receives m coins from Bob, or both parties receive none.

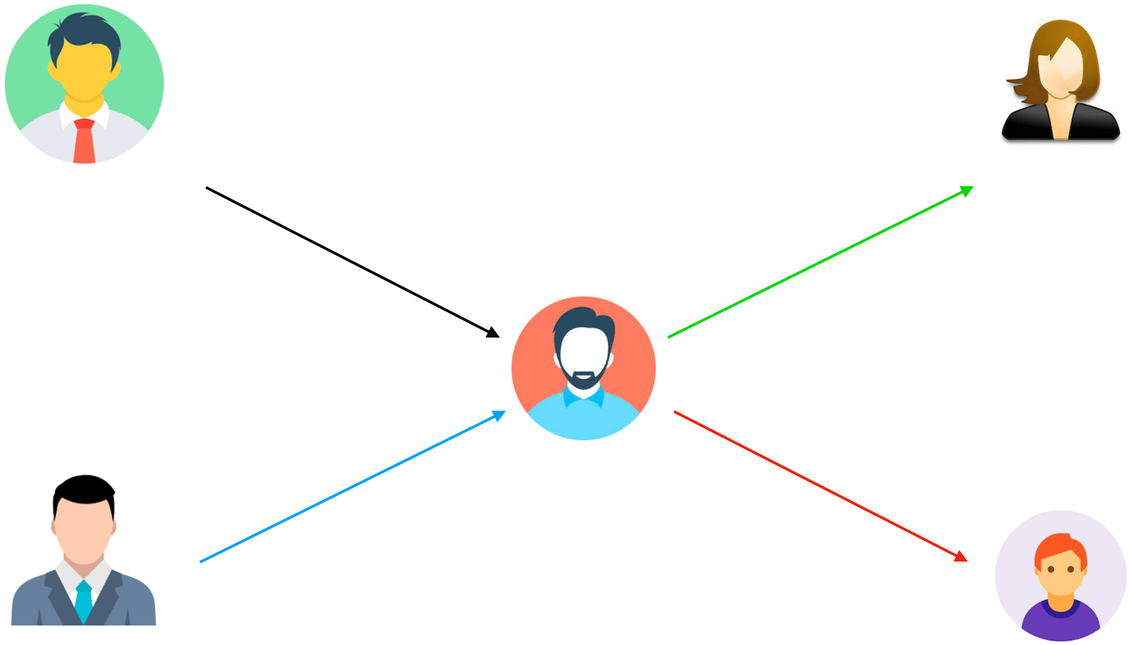


Or



Payment Channel Hub

- Relationship Anonymity: the hub should not learn who is paying to whom



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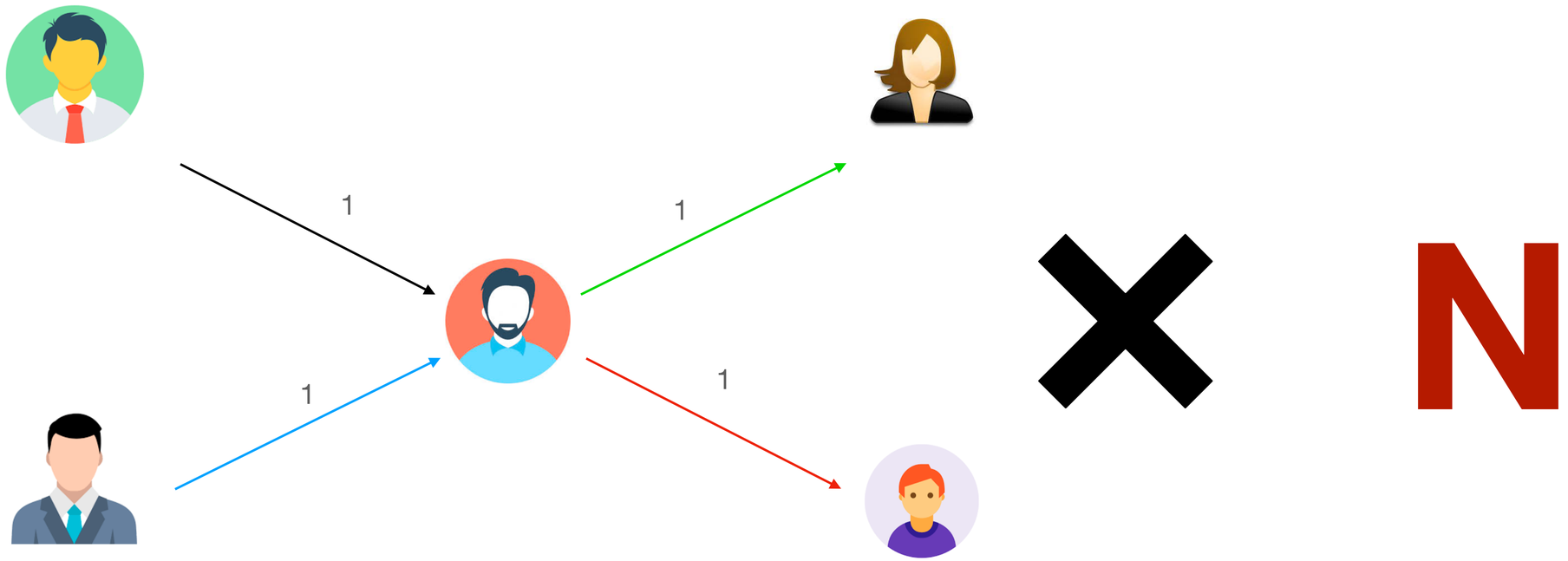

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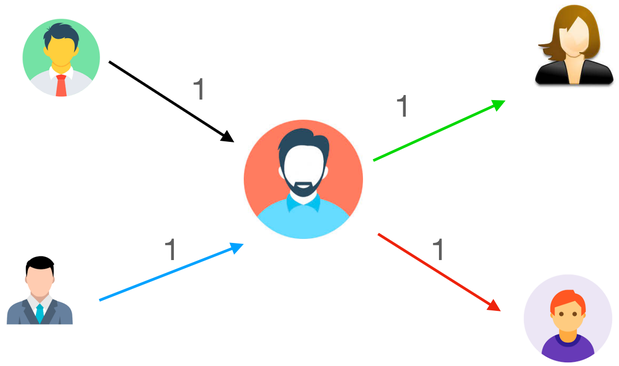
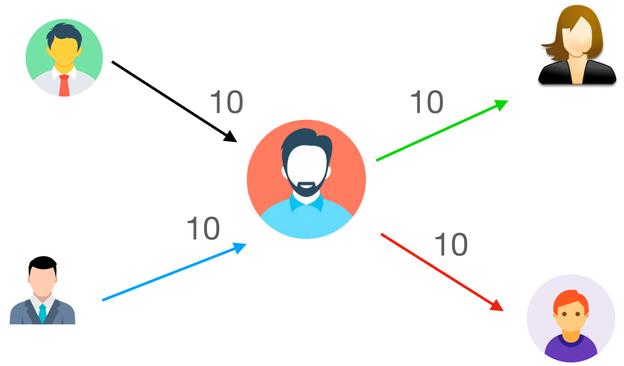
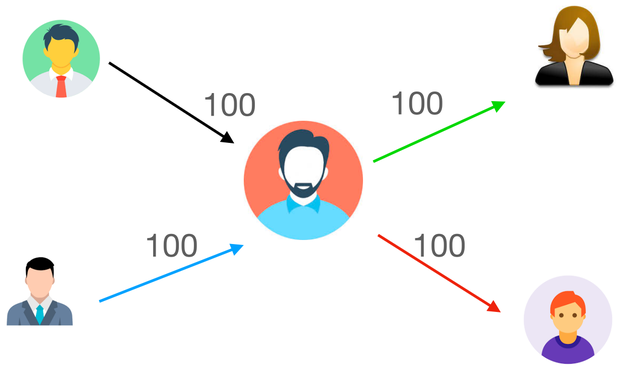
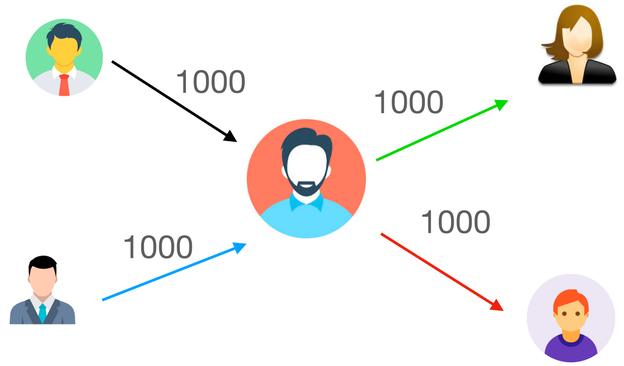


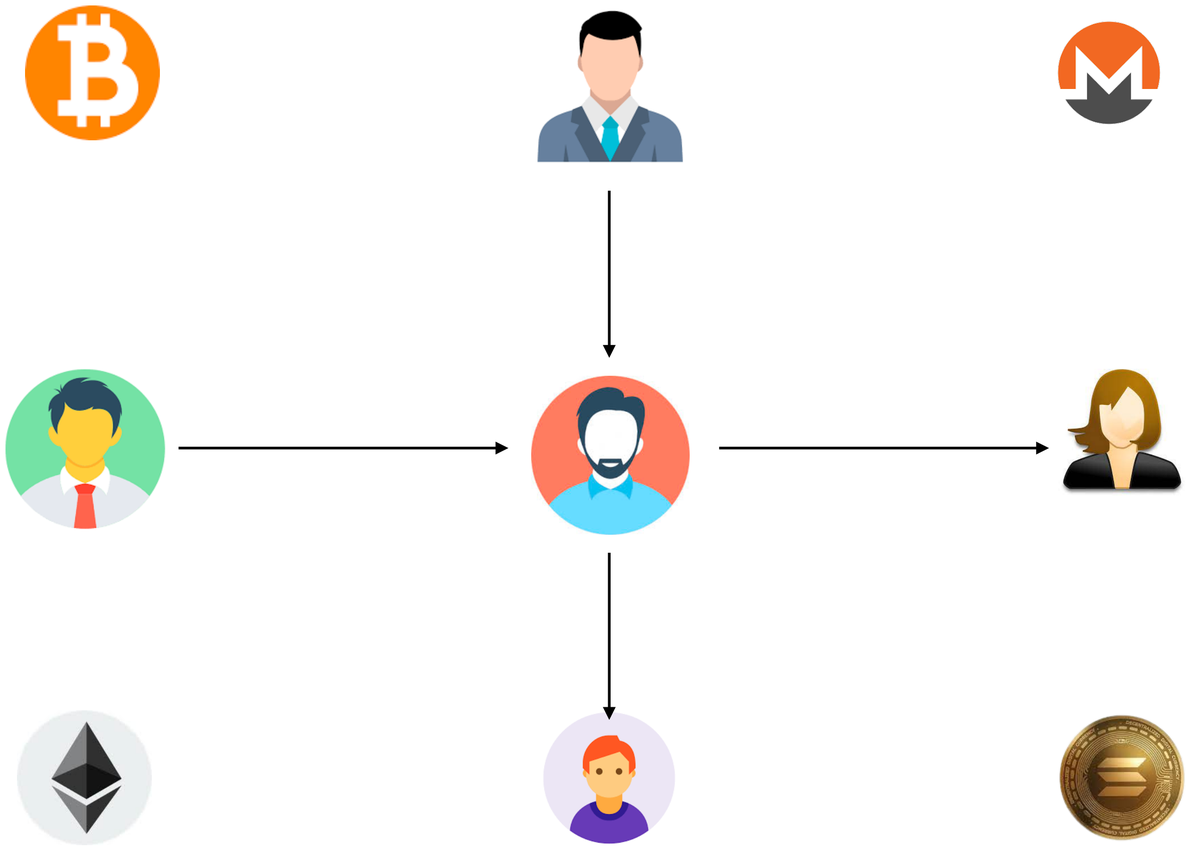






Payment Channel Hub

- Interoperability: The PCH should support as many cryptocurrencies as possible.



State-of-the-art and Comparison

	Bitcoin Compatible	Relationship Anonymous	Atomic	Flexible (Variable Amount)
A2L [TMM 21, S&P] TumbleBit [HABSG 17, NDSS]				
BOLT [GM 17, CCS]				
This Work				

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This Work	✓	✓	✓	✓

Our Solution

BlindChannel—Hiding the amount

BlindChannel

BlindChannel

Recall normal payment channel…

BlindChannel

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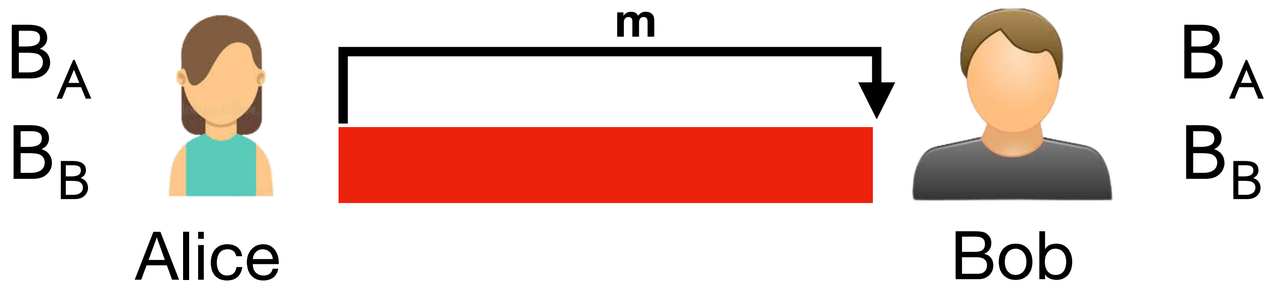

BlindChannel

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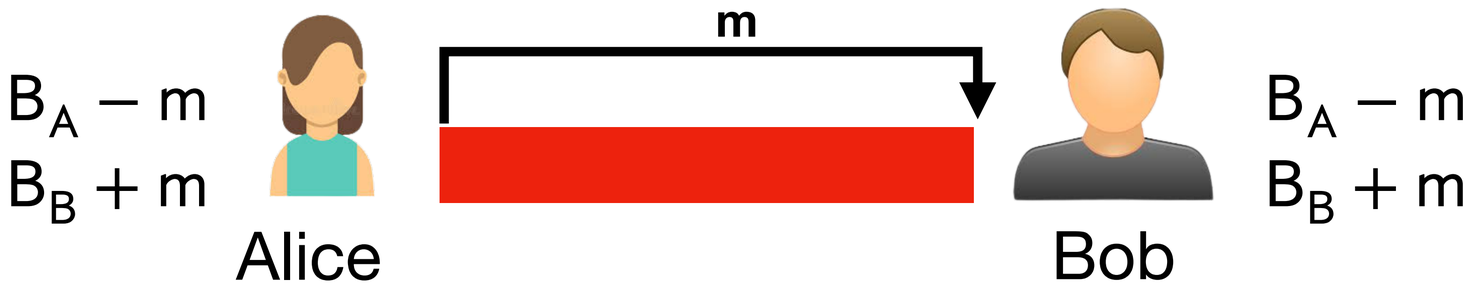

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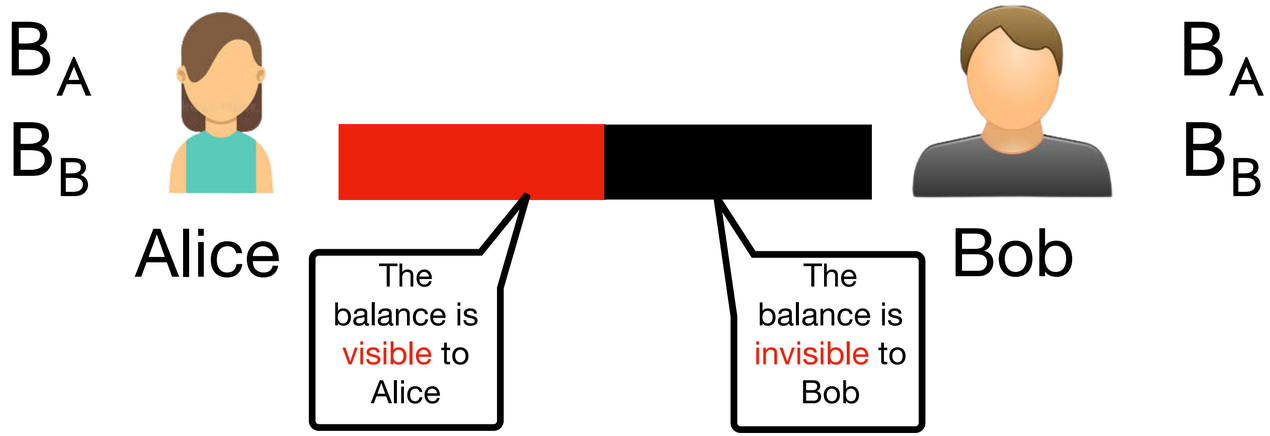

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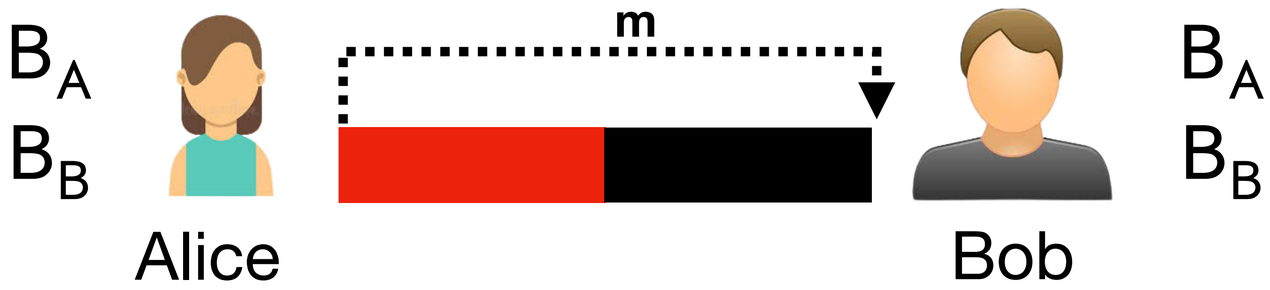

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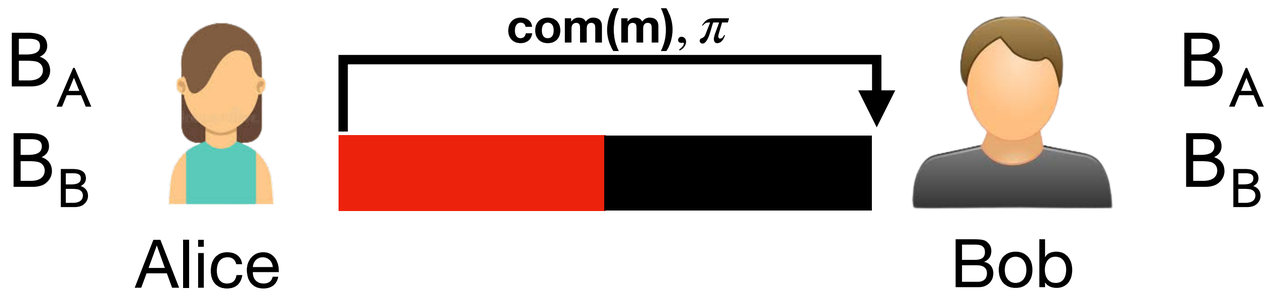

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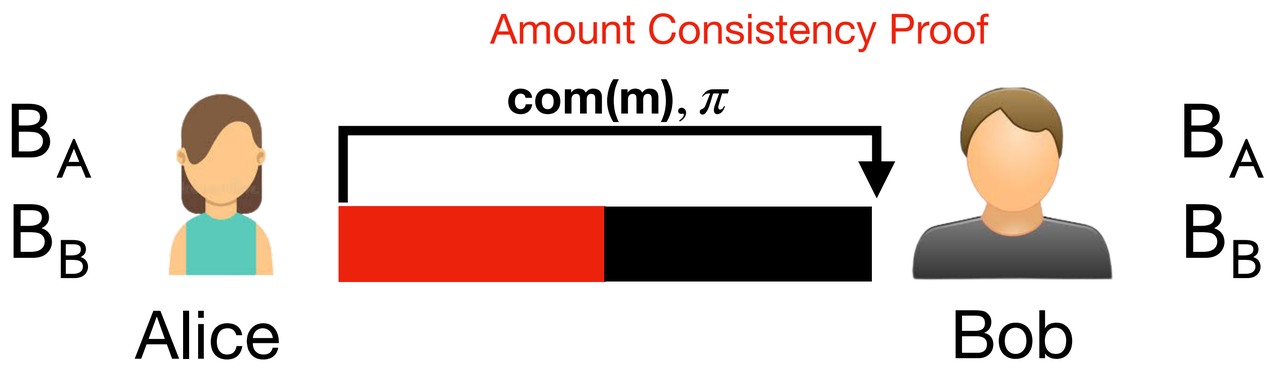

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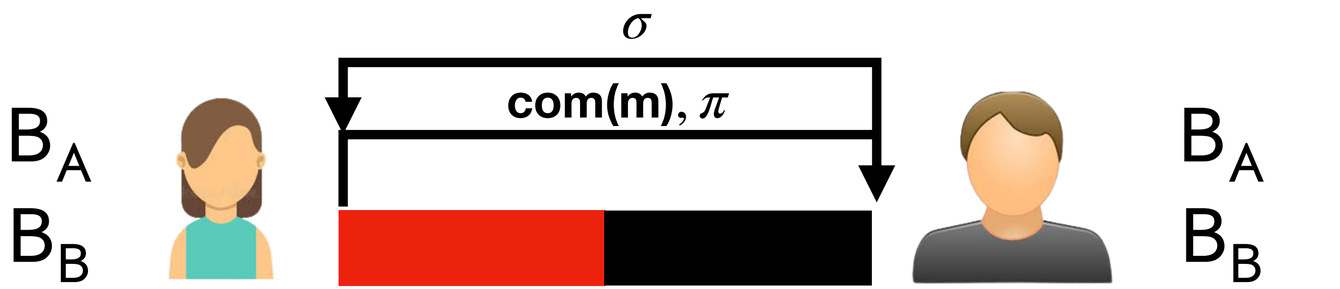

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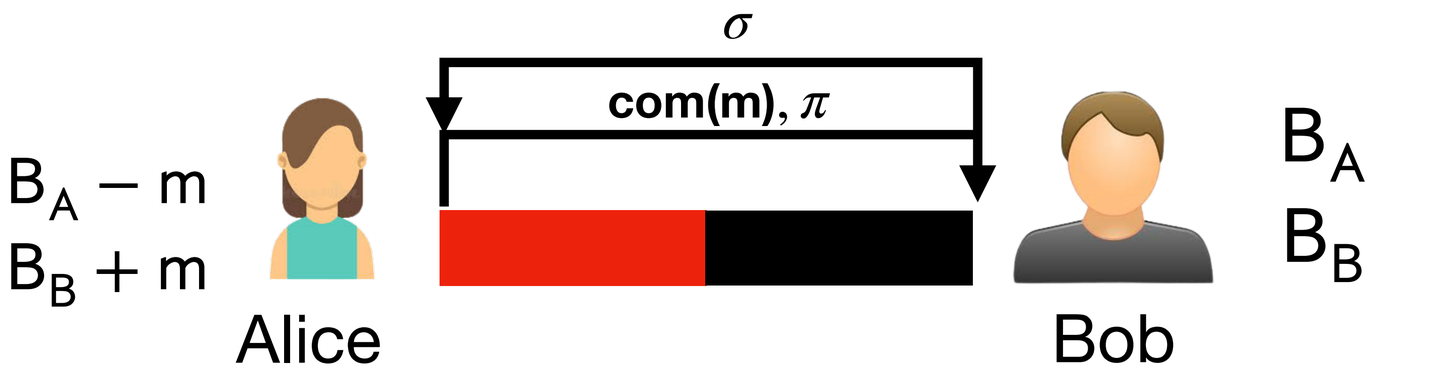

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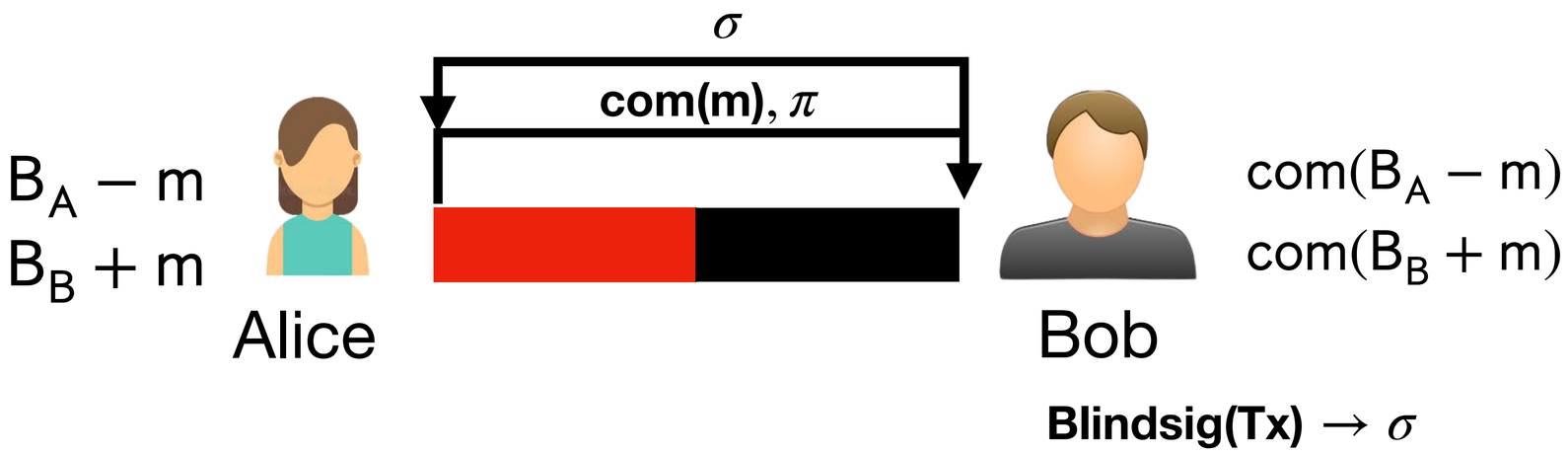
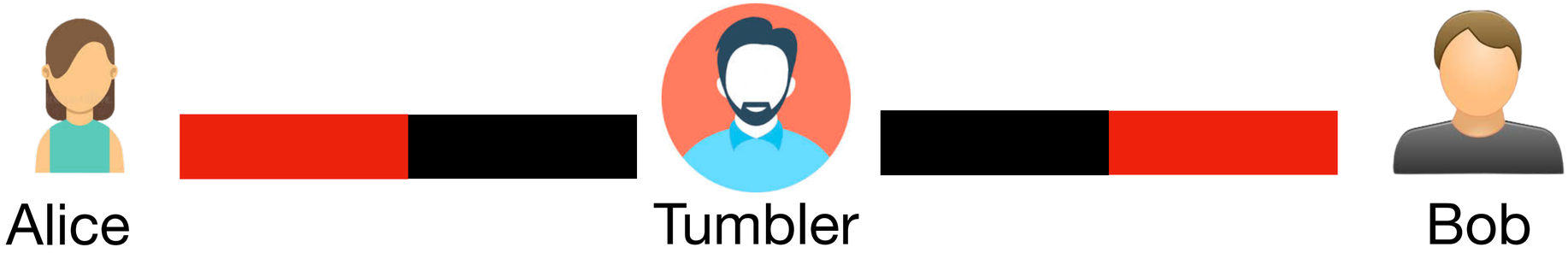


PCH with BlindChannel (Naive version)



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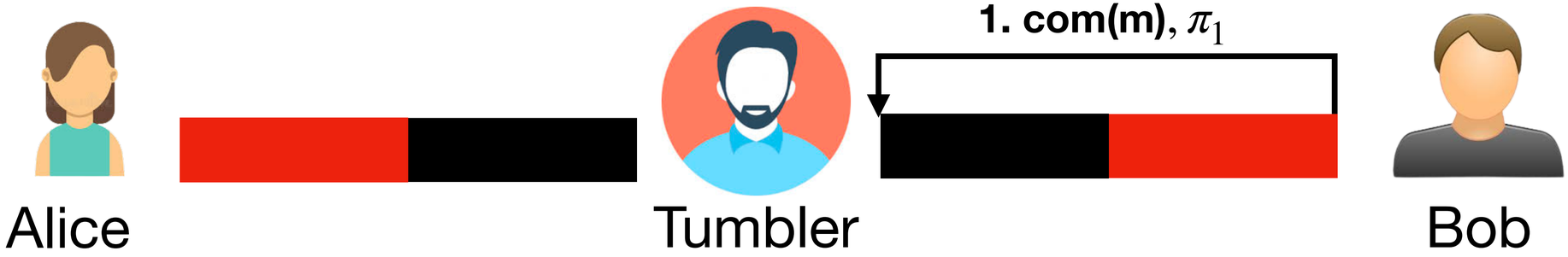

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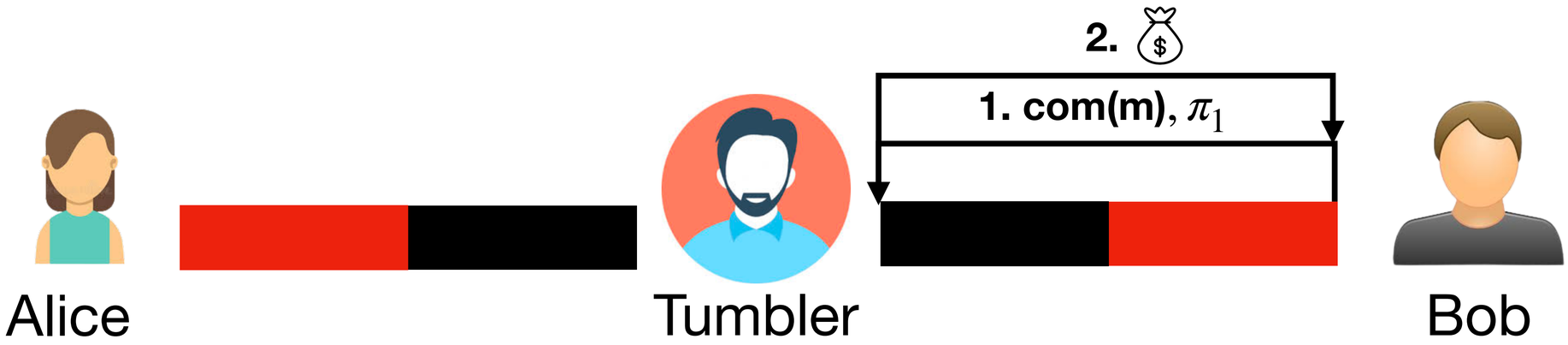

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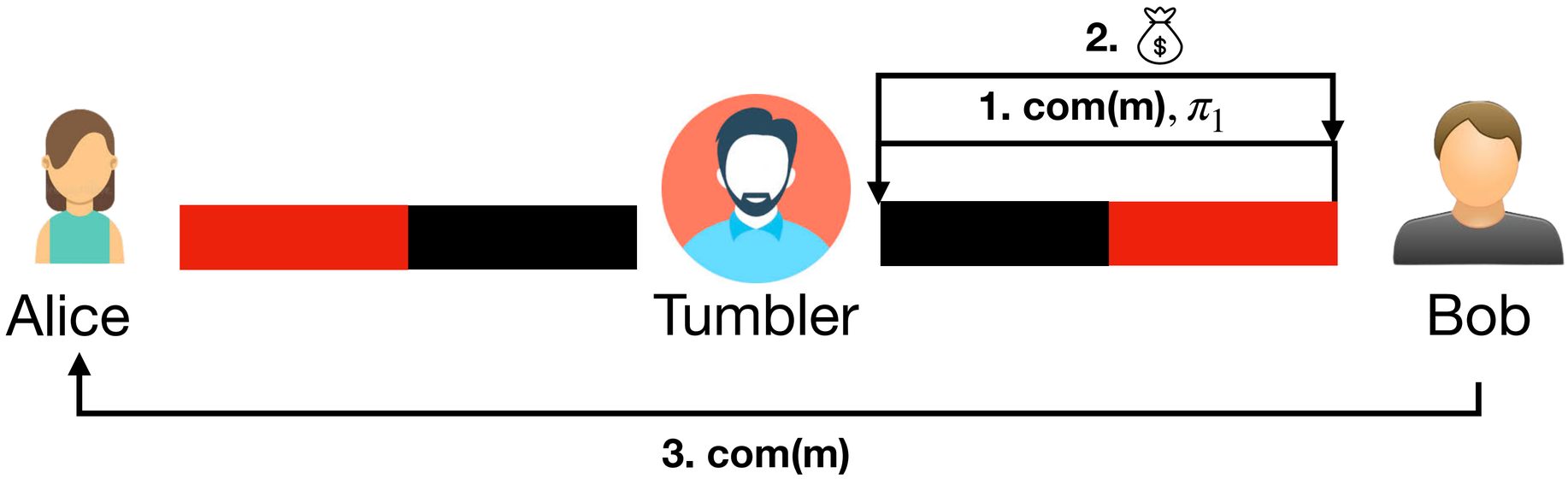

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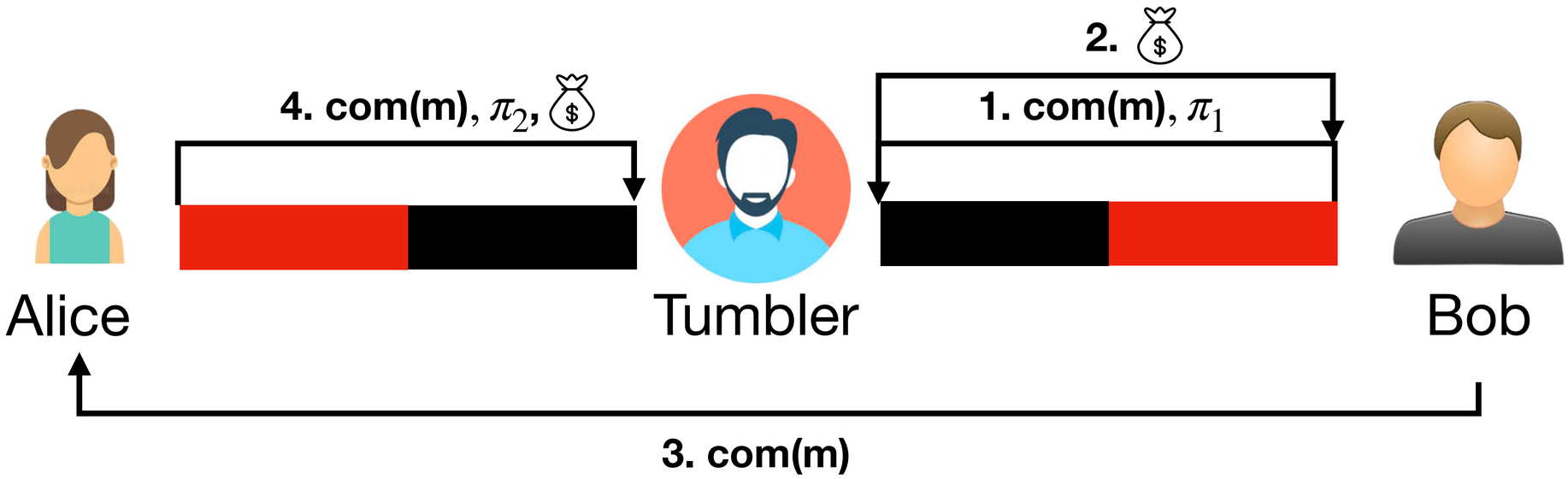

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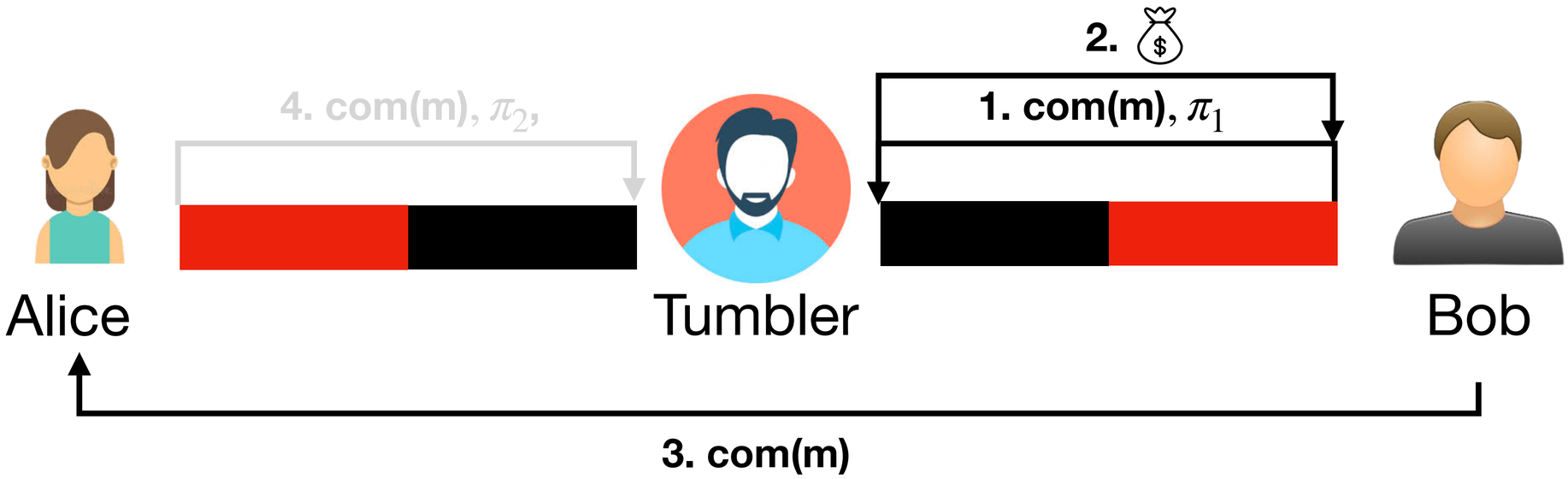

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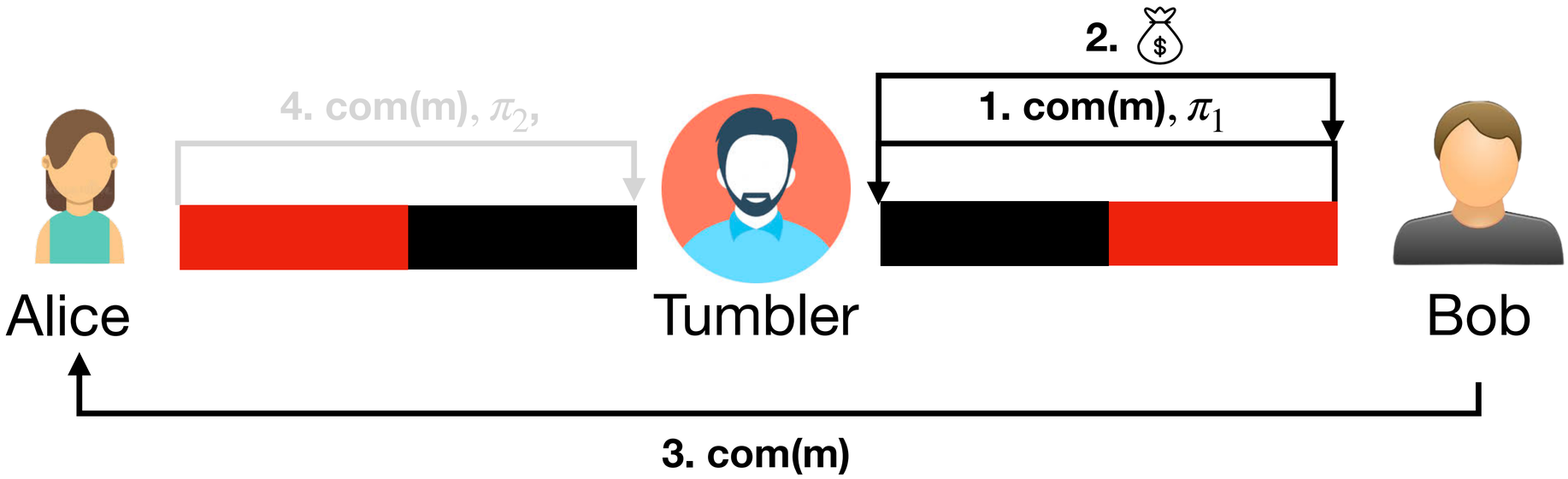

No Atomicity!

Prelim: Adaptor Signature [AEEFHMMR’ 20]

Relation

$(Y, y) \in R$

(sk, pk)

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Y, m

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PreSig$(m, \mathsf{sk}, Y) \to \hat{\sigma}$

Incomplete Signature

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$\hat{\sigma}$

$\text{PreVfy}(m, \text{pk}, Y, \hat{\sigma}) \to 0/1$

$\text{Adapt}(\hat{\sigma}, y) \to \sigma$

Incomplete Signature

Complete Signature

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m, σ

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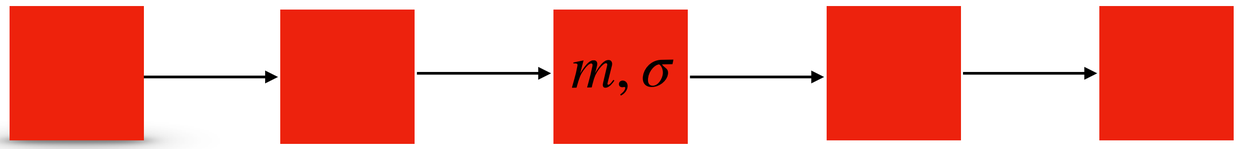
m, σ

σ



Prelim: Adaptor Signature [AEEFHMMR' 20]

Relation

$(Y, y) \in R$

(sk, pk)

Y, m

$\text{PreSig}(m, \text{sk}, Y) \to \hat{\sigma}$

$\hat{\sigma}$

$\text{PreVfy}(m, \text{pk}, Y, \hat{\sigma}) \to 0/1$

Incomplete Signature

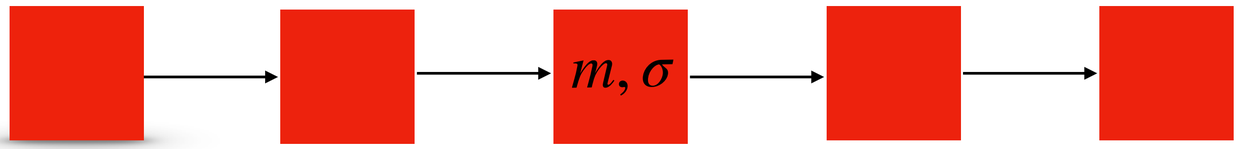
$\text{Adapt}(\hat{\sigma}, y) \to \sigma$

$\text{Extract}(\hat{\sigma}, \sigma) \to y$

m, σ

σ

Complete Signature



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σ

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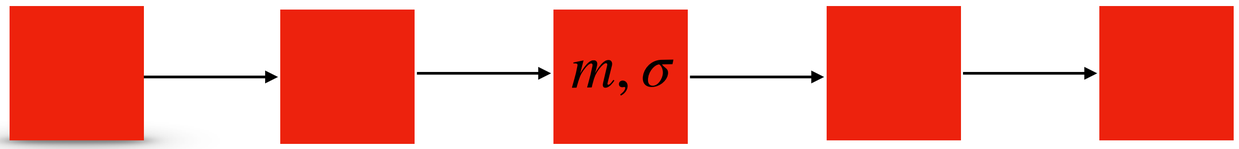


Blind Adaptor Signature

Relation

$(Y, y) \in R$

(sk, pk)

Y, m

$\text{PreSig}(m, \text{sk}, Y) \to \hat{\sigma}$

$\hat{\sigma}$

$\text{PreVfy}(m, \text{pk}, Y, \hat{\sigma}) \to 0/1$

Incomplete Signature

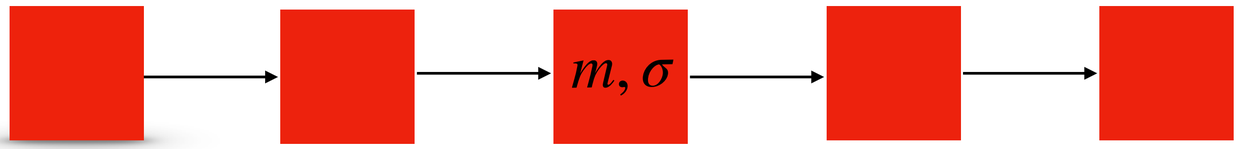
$\text{Adapt}(\hat{\sigma}, y) \to \sigma$

$\text{Adapt}(\hat{\sigma}, y) \to \sigma$

m, σ

σ

Complete Signature



Blind Adaptor Signature

Relation

$(Y, y) \in R$

(sk, pk)

$Y, \text{com}(m), \pi$

$\text{PreSig}(\text{com}(m), \text{sk}, Y) \rightarrow \hat{\sigma}$

$\hat{\sigma}$

$\text{PreVfy}(m, \text{pk}, Y, \hat{\sigma}) \rightarrow 0/1$

$\text{Adapt}(\hat{\sigma}, y) \rightarrow \sigma$

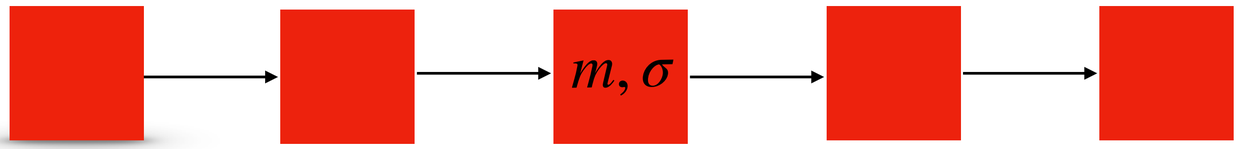
Incomplete Signature

Complete Signature

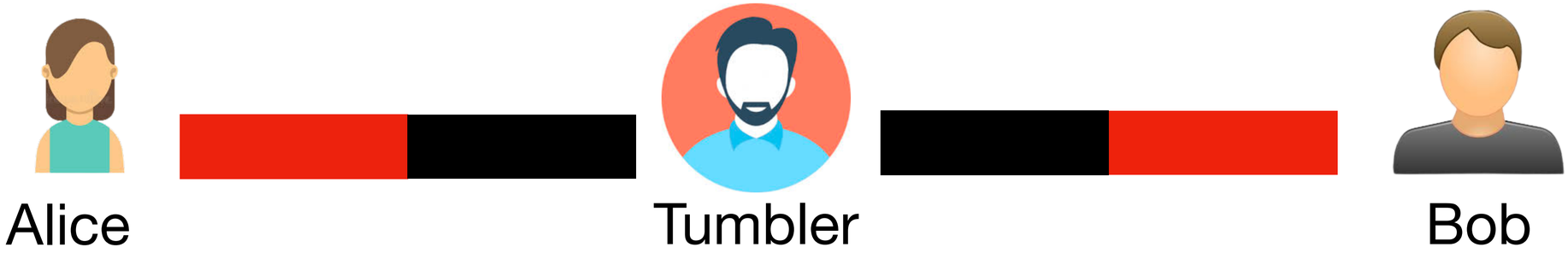
m, σ

σ

$\text{Adapt}(\hat{\sigma}, y) \rightarrow \sigma$



PCH with BlindChannel+Atomicity



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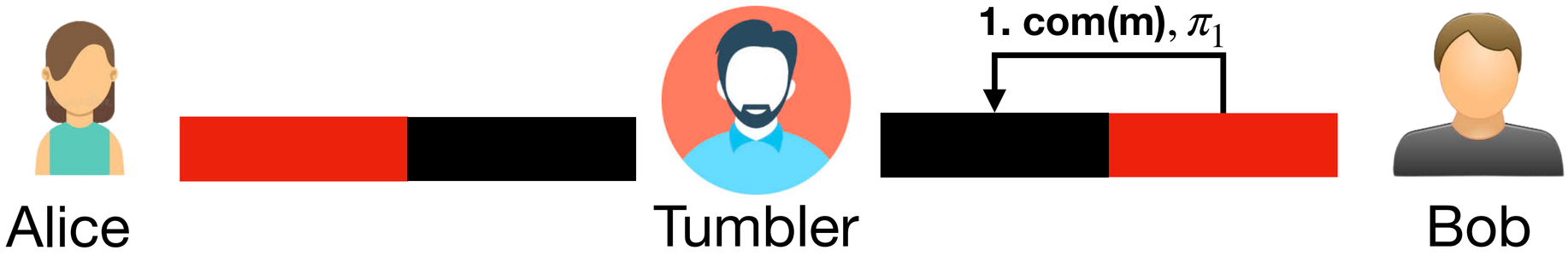

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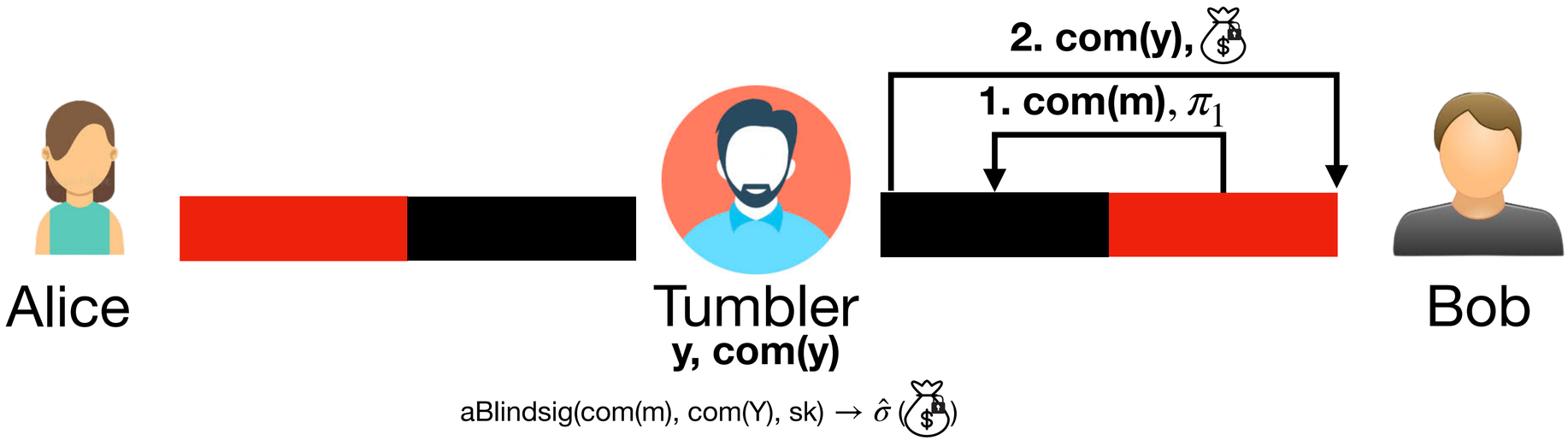

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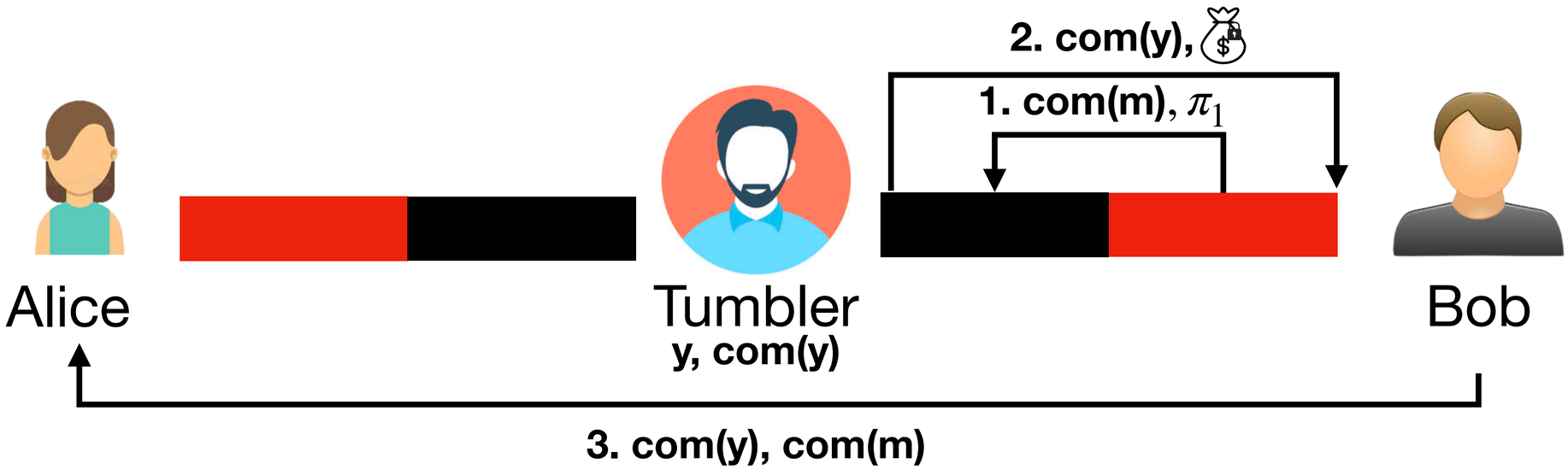

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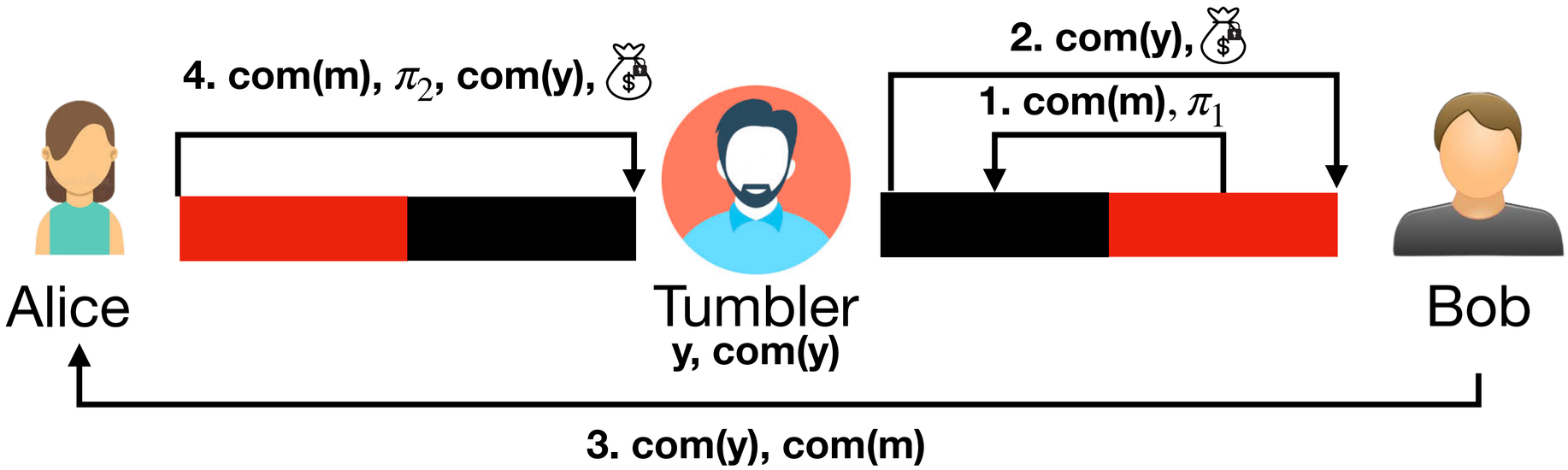

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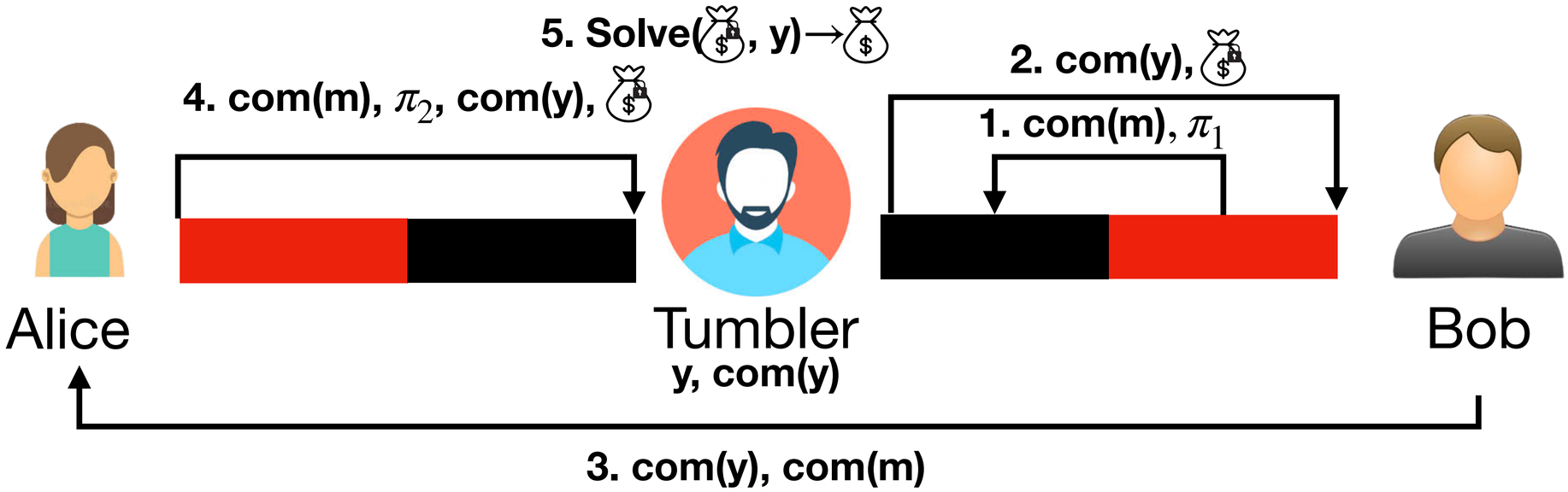
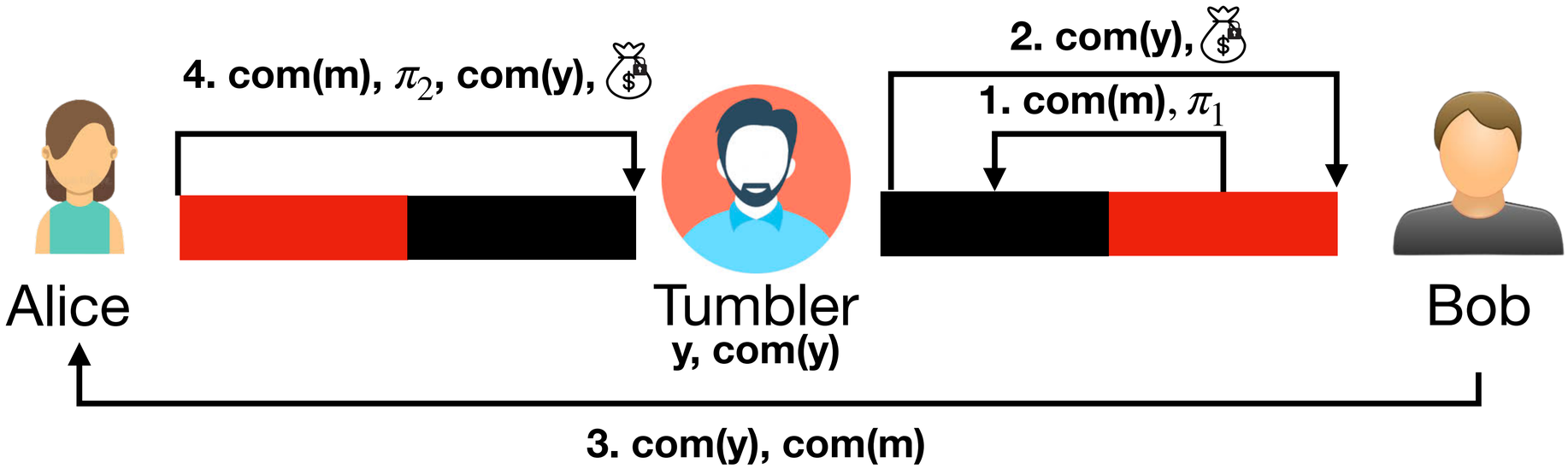
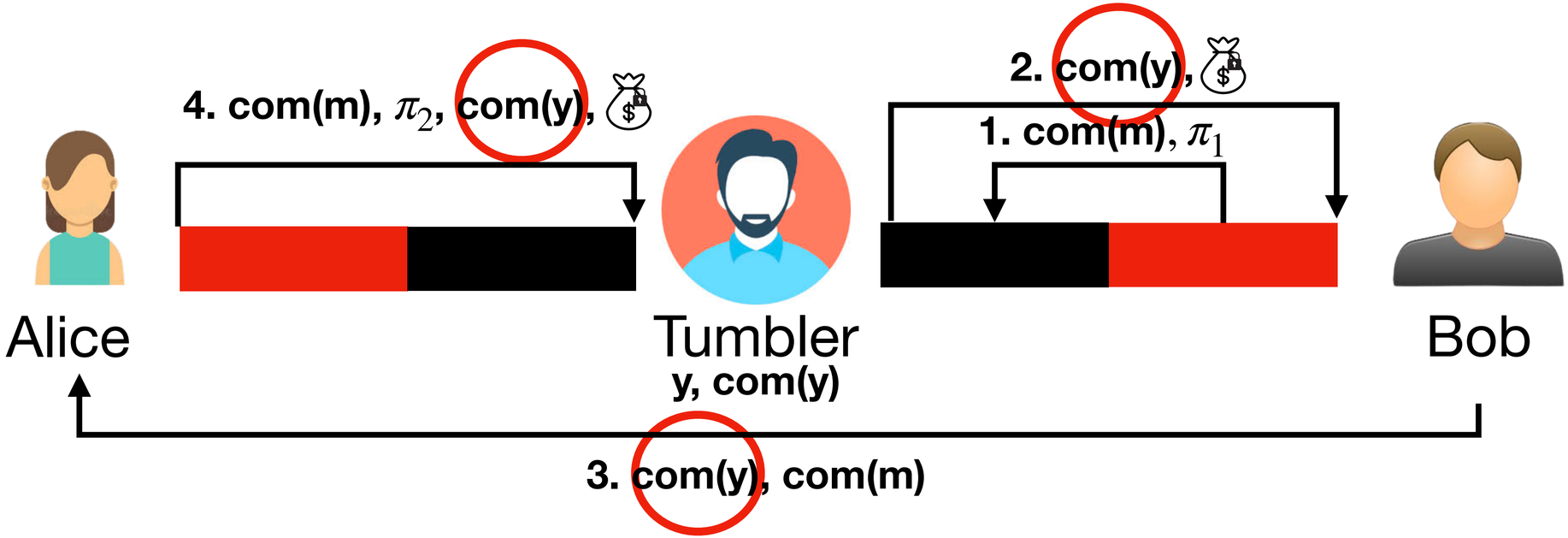


PCH with BlindChannel+Atomicity+Privacy



PCH with BlindChannel+Atomicity+Privacy



Building blocks for Privacy

- Randomizable puzzle

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$$com(\zeta), enc(\zeta) \rightarrow com(\zeta), enc(\zeta)$$

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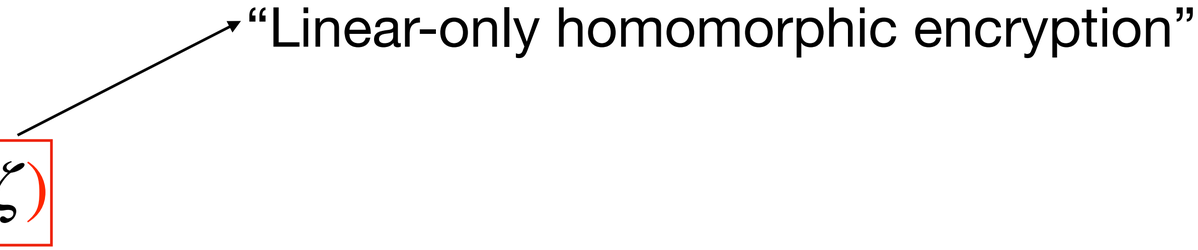


Building blocks for Privacy

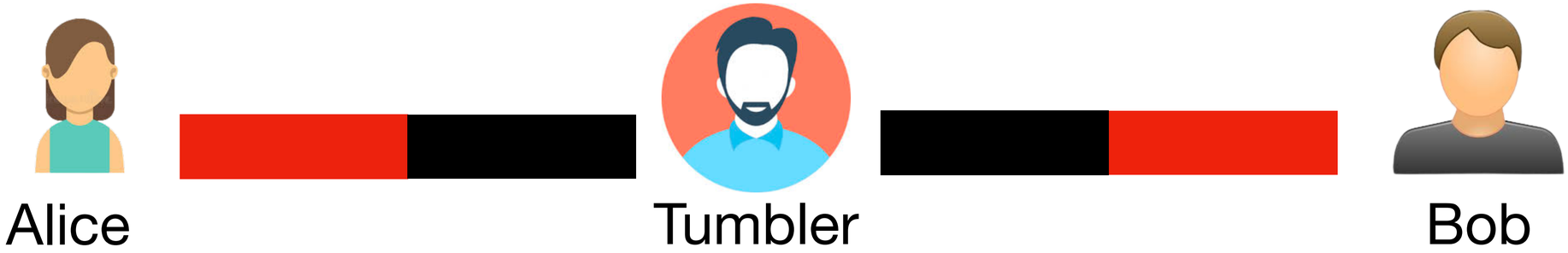
- Randomizable puzzle

$$com(\zeta), enc(\zeta) \rightarrow com(\zeta), enc(\zeta)$$

- Randomizable signature on randomizable commitment

$$(\sigma, com(\zeta), com(\zeta)) \rightarrow (\sigma, com(\zeta), com(\zeta))$$

PCH with BlindChannel+Atomicity+Privacy



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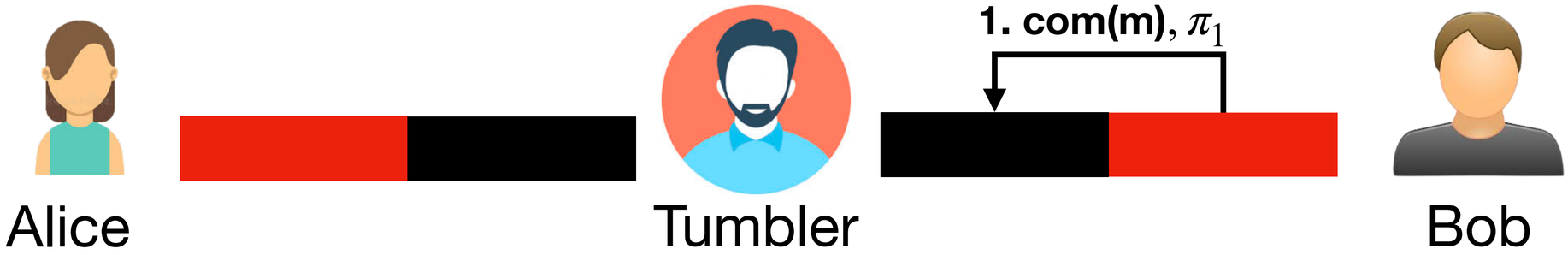

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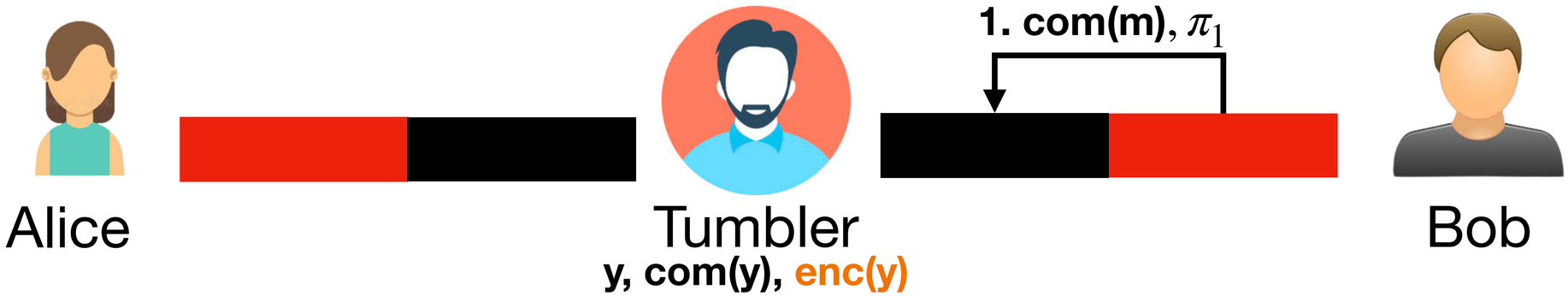

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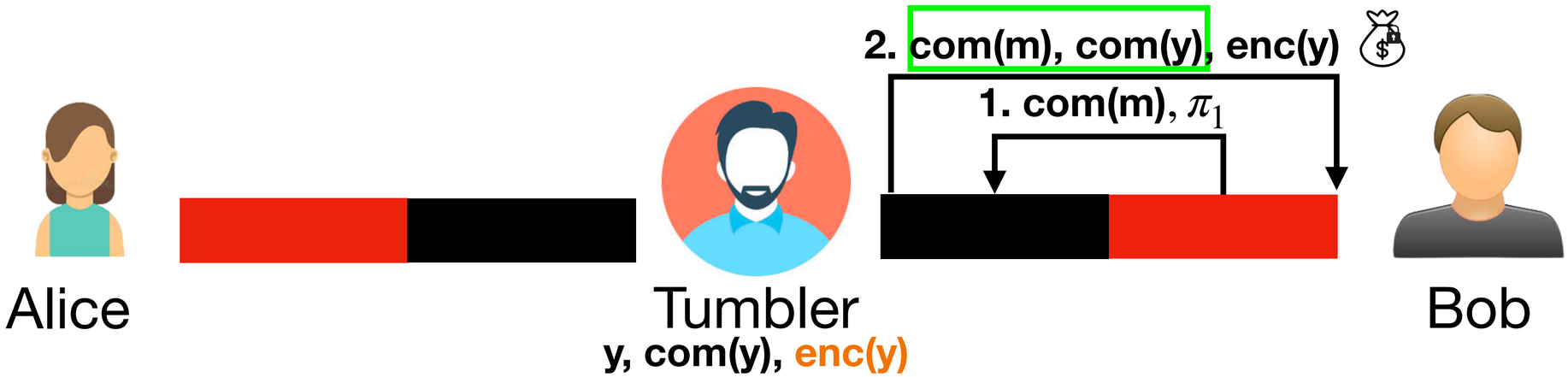

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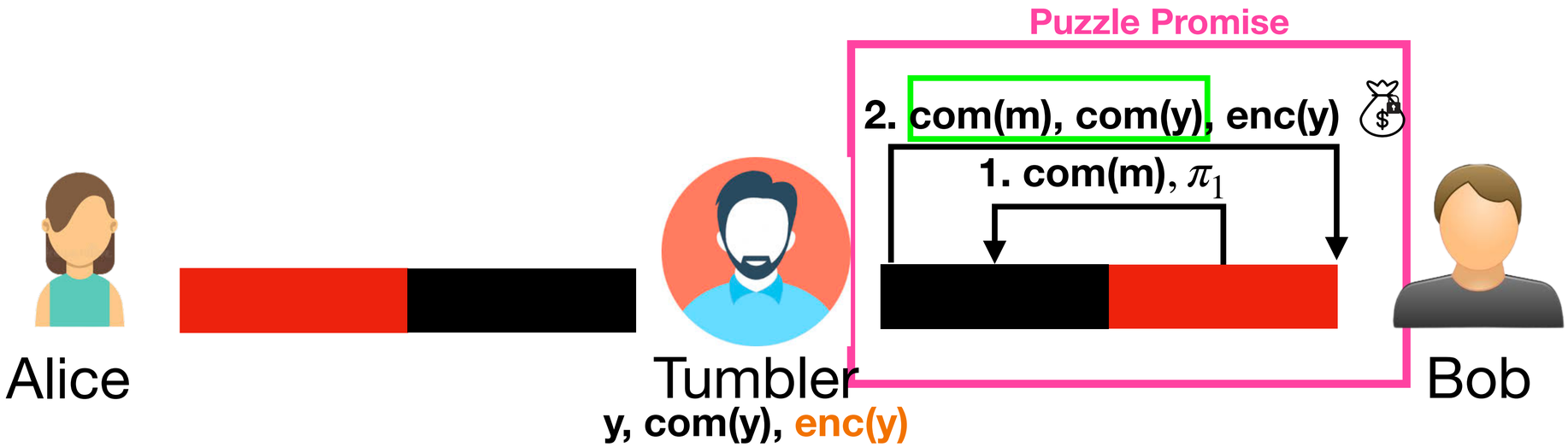

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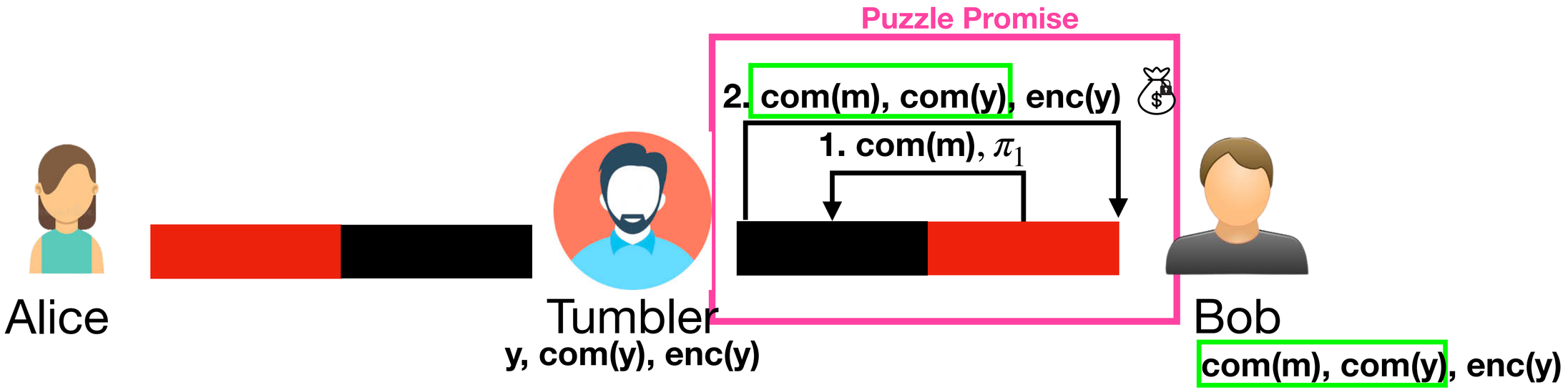

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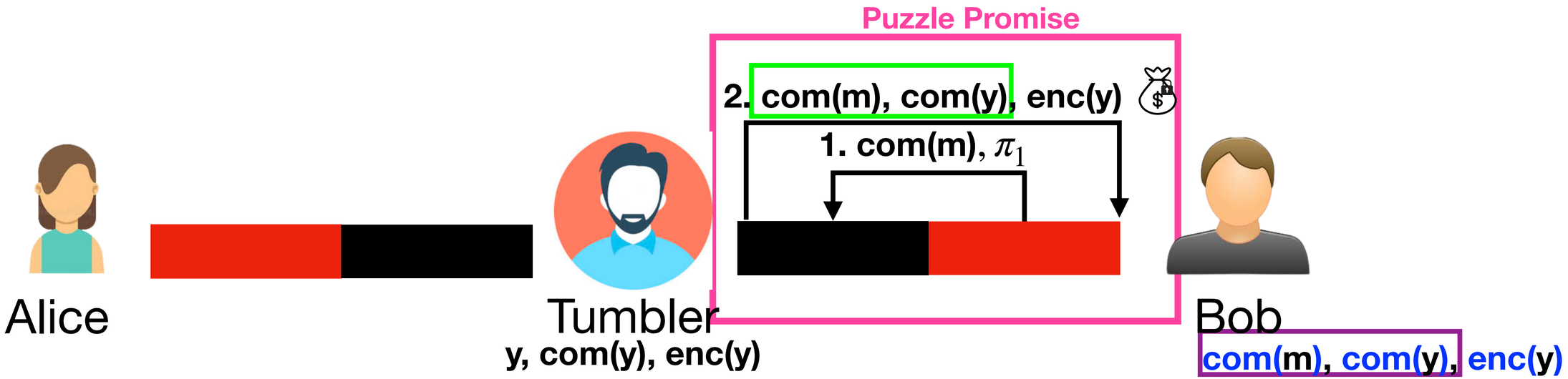

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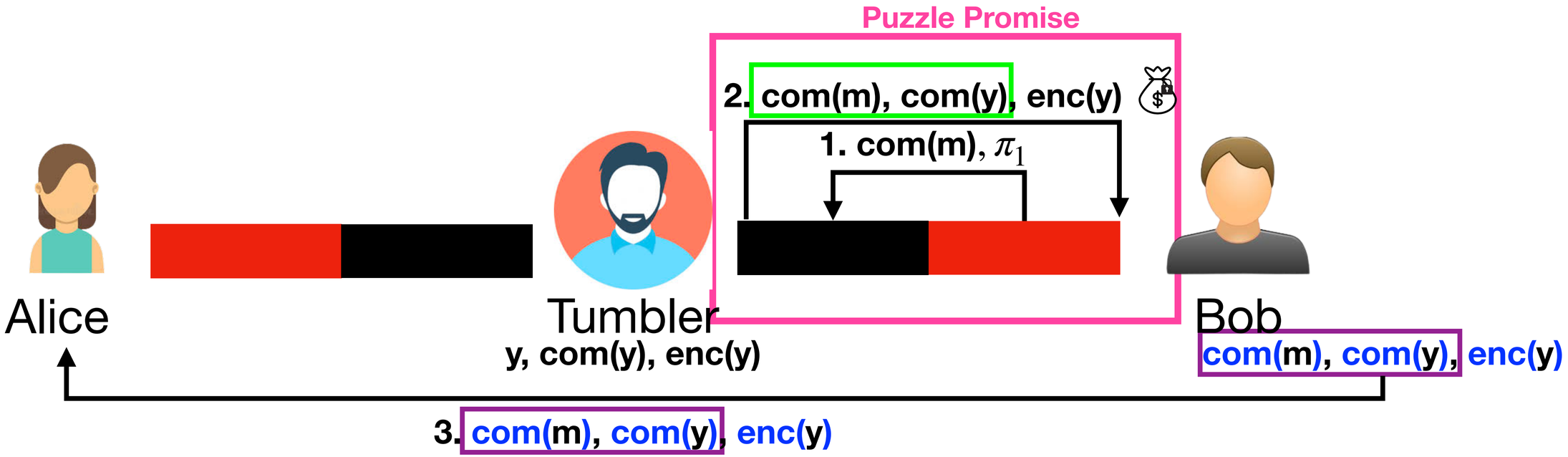

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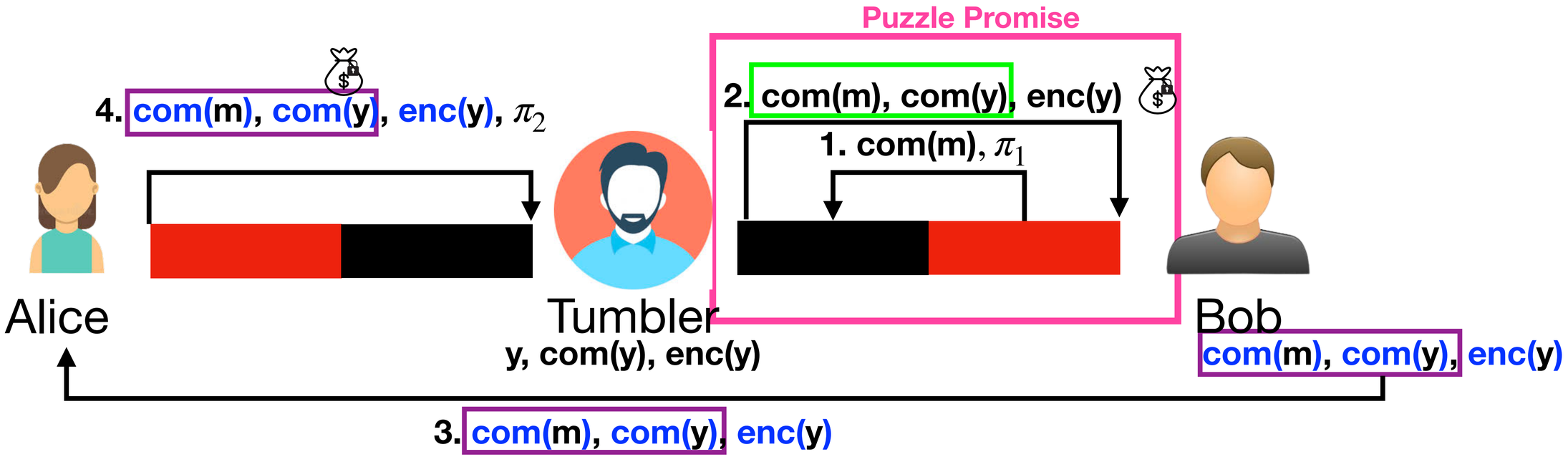

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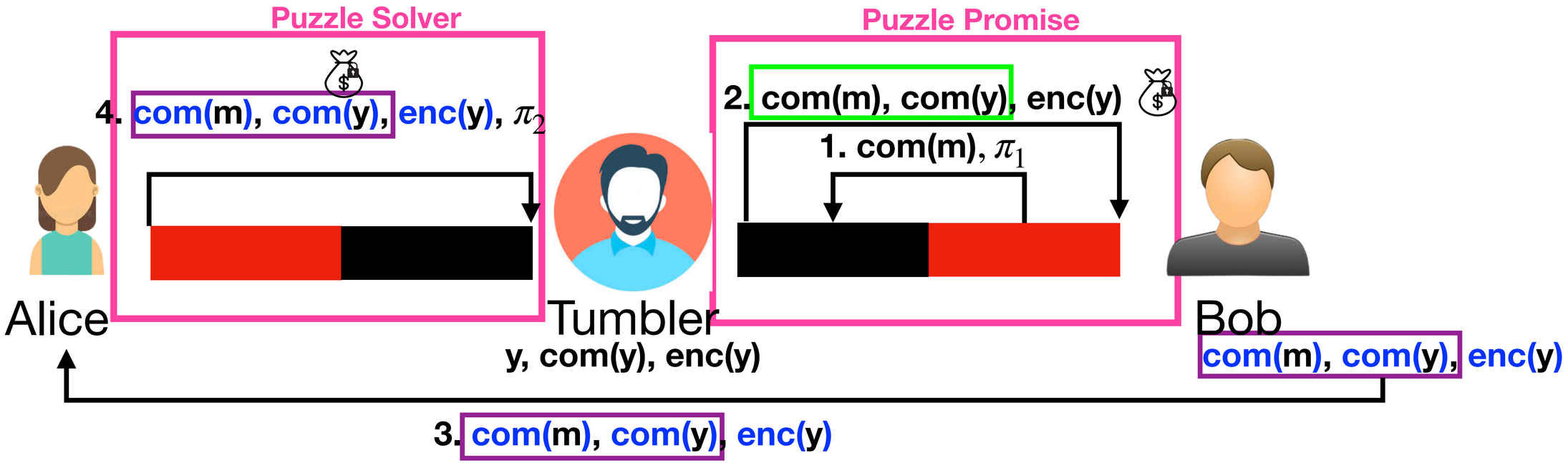
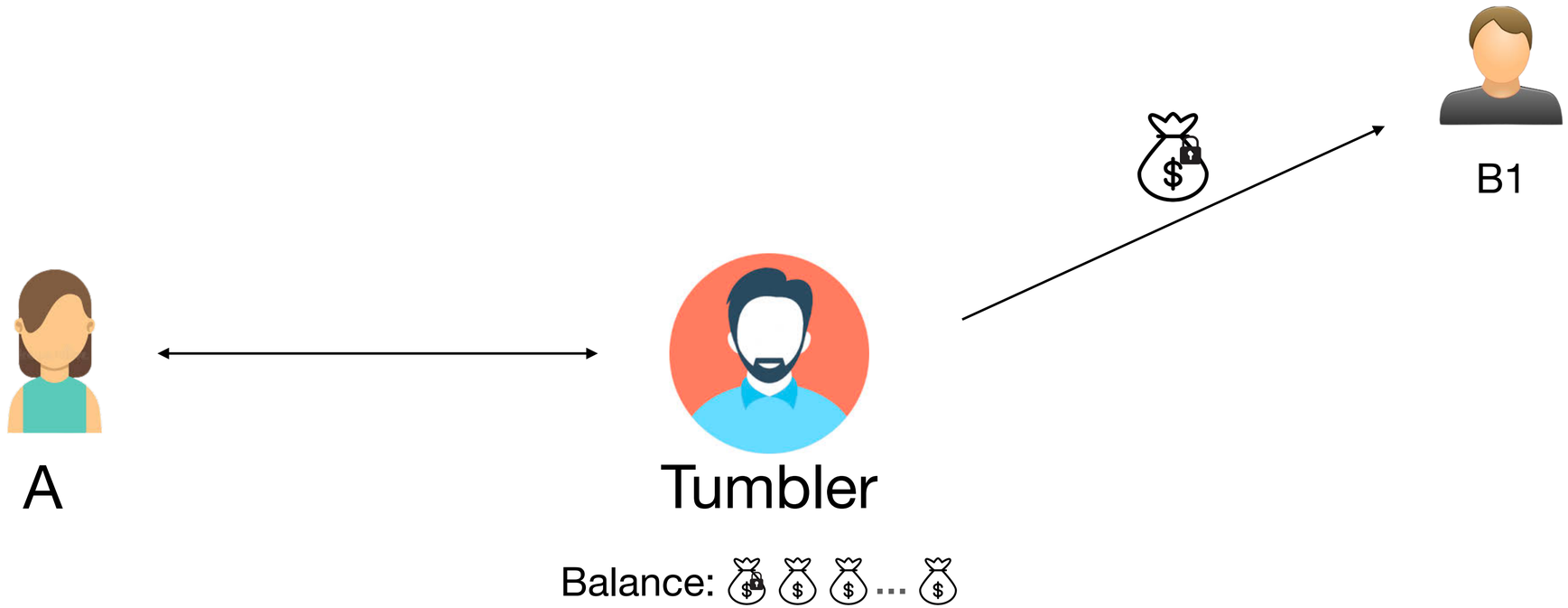


PCH with BlindChannel+Atomicity+Privacy+Griefing Resistance

Griefing Attack



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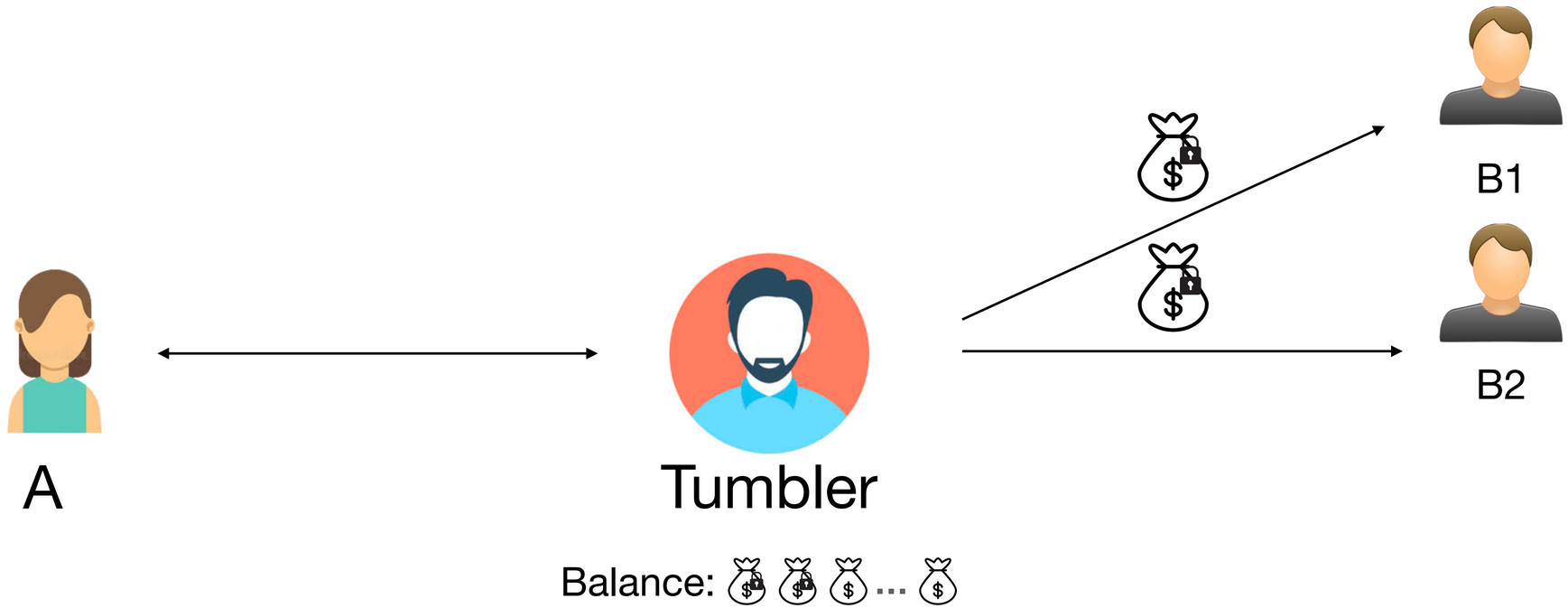

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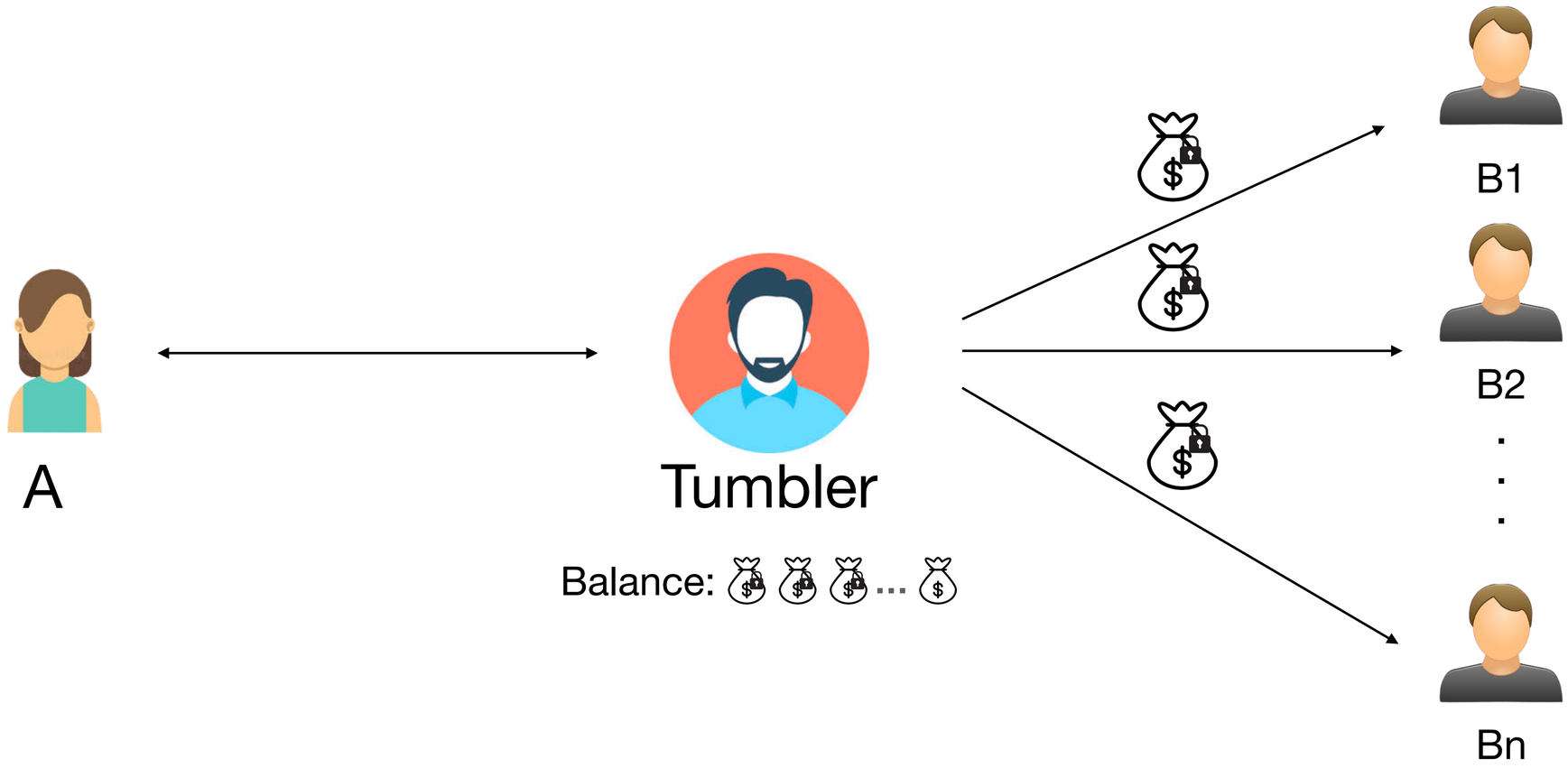

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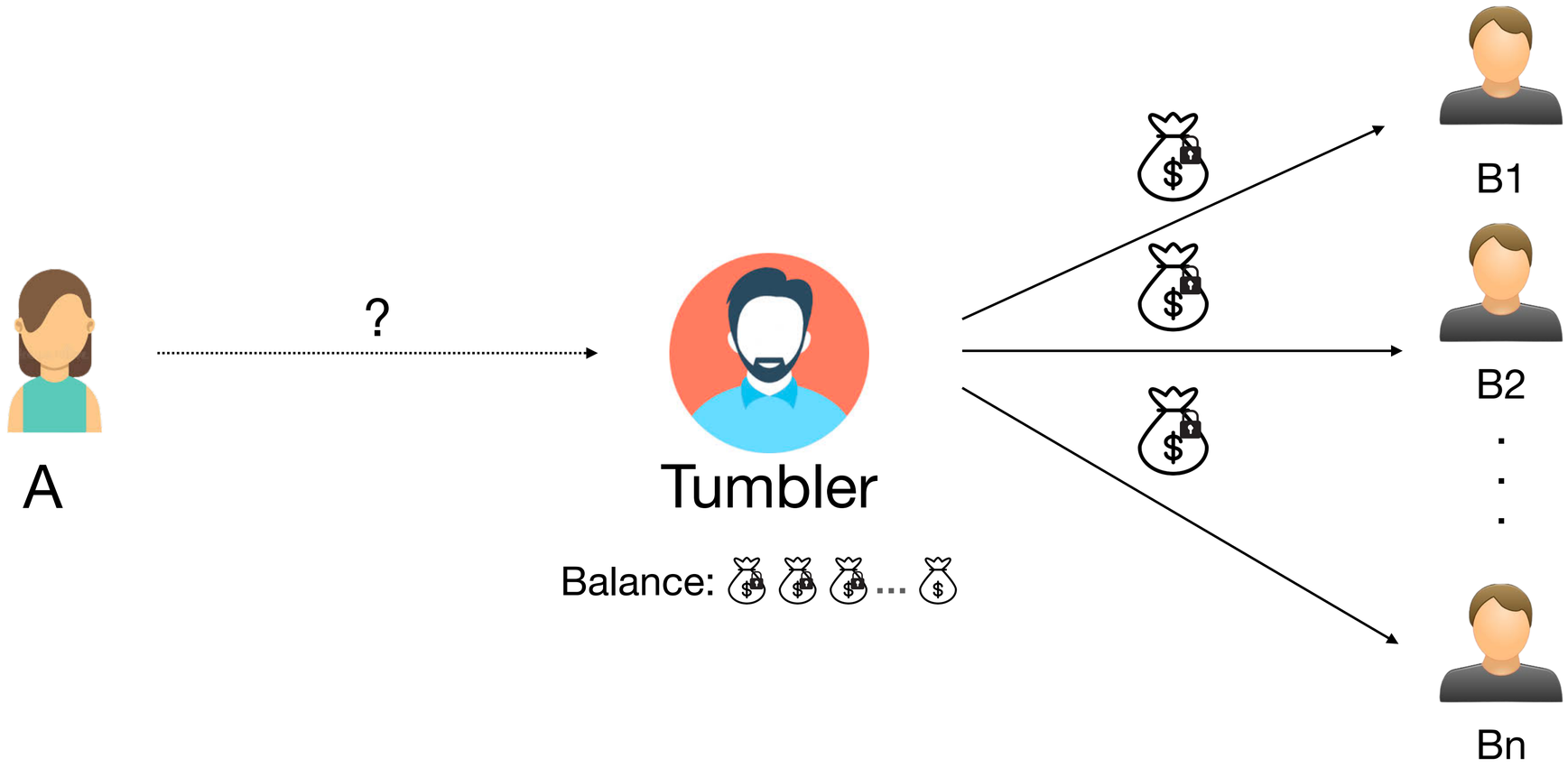
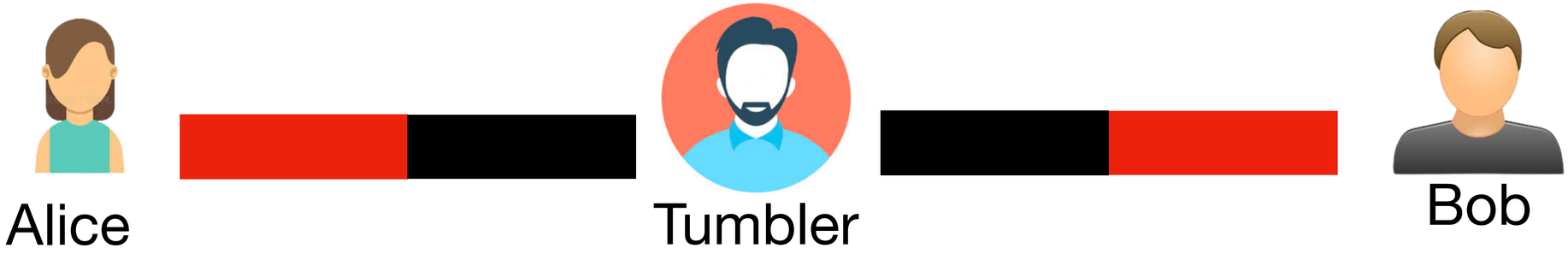


PCH with BlindChannel+Atomicity+Privacy+Griefing Resistance

Registration



PCH with BlindChannel+Atomicity+Privacy+Griefing Resistance

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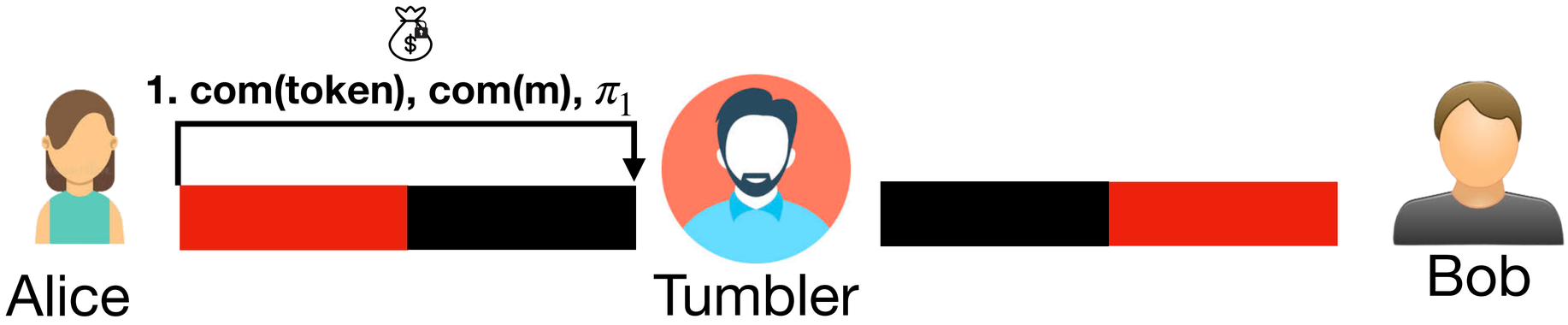

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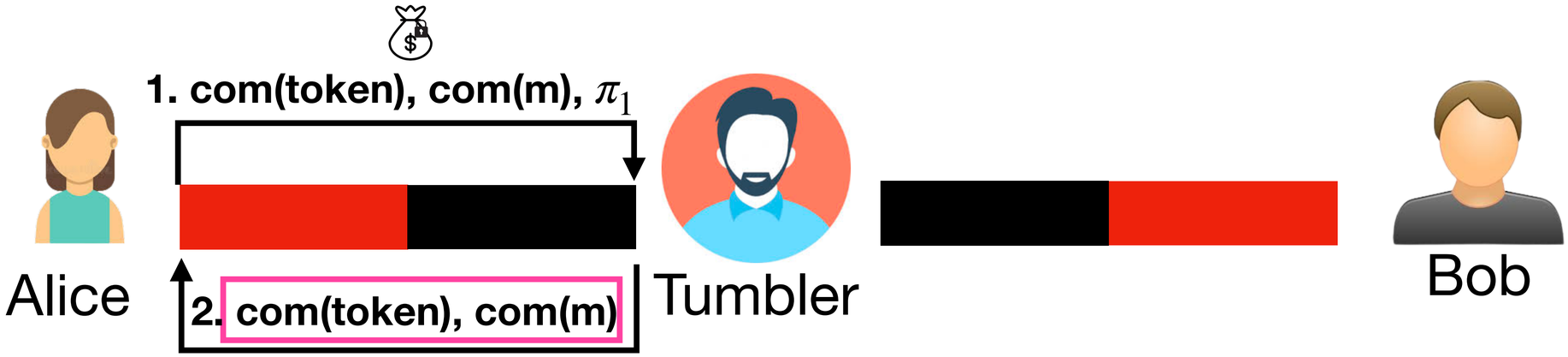

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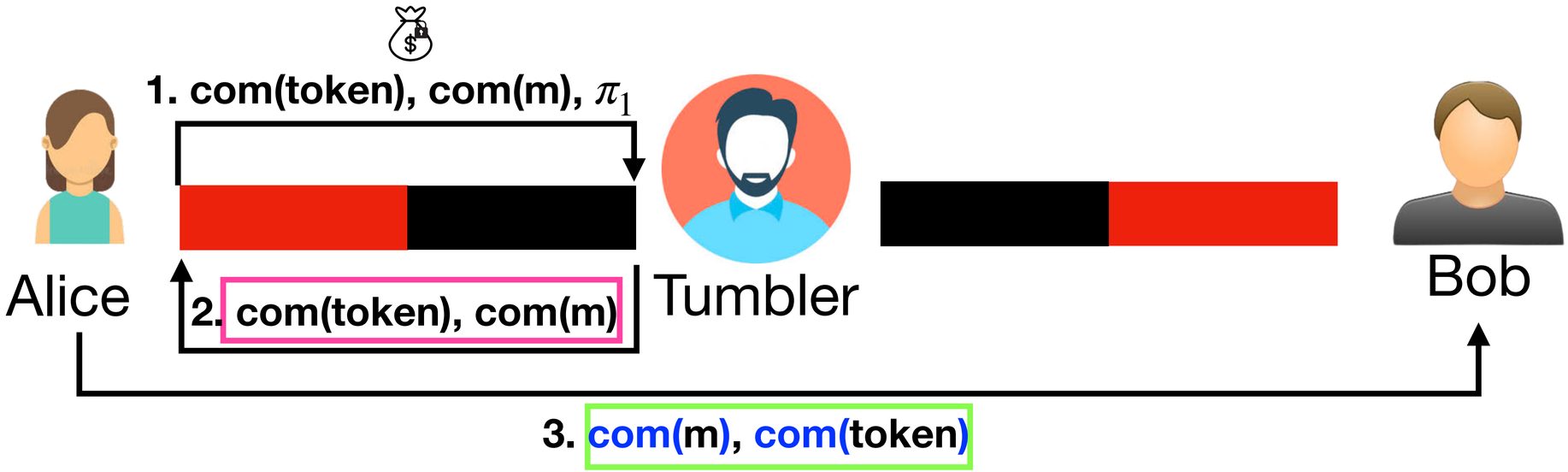
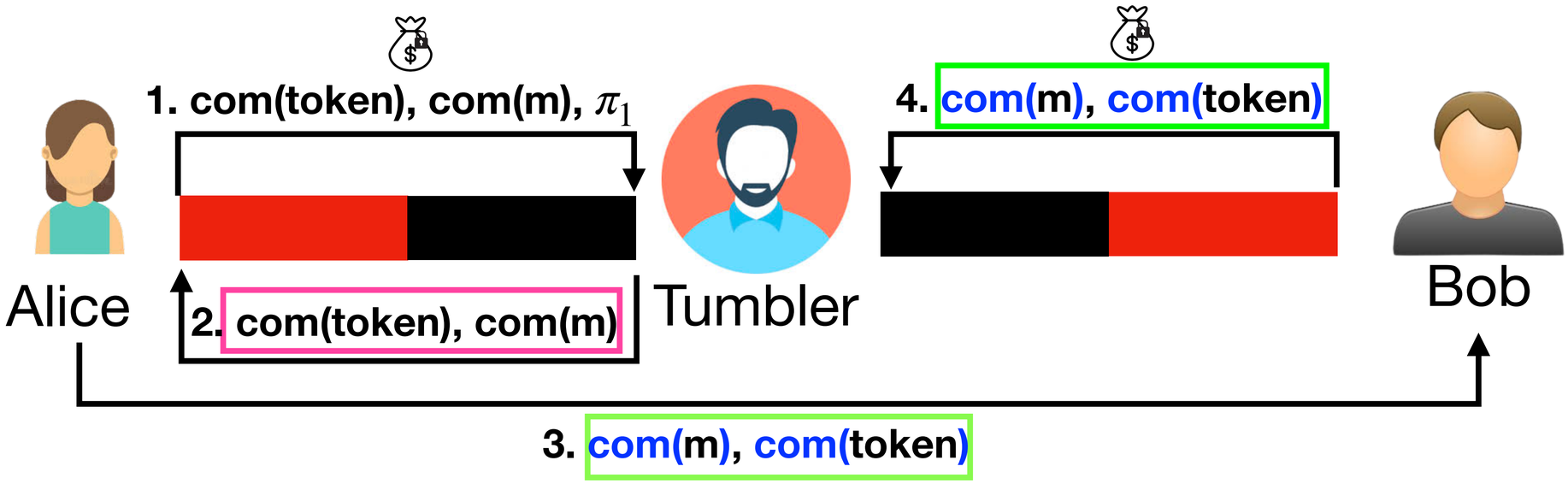
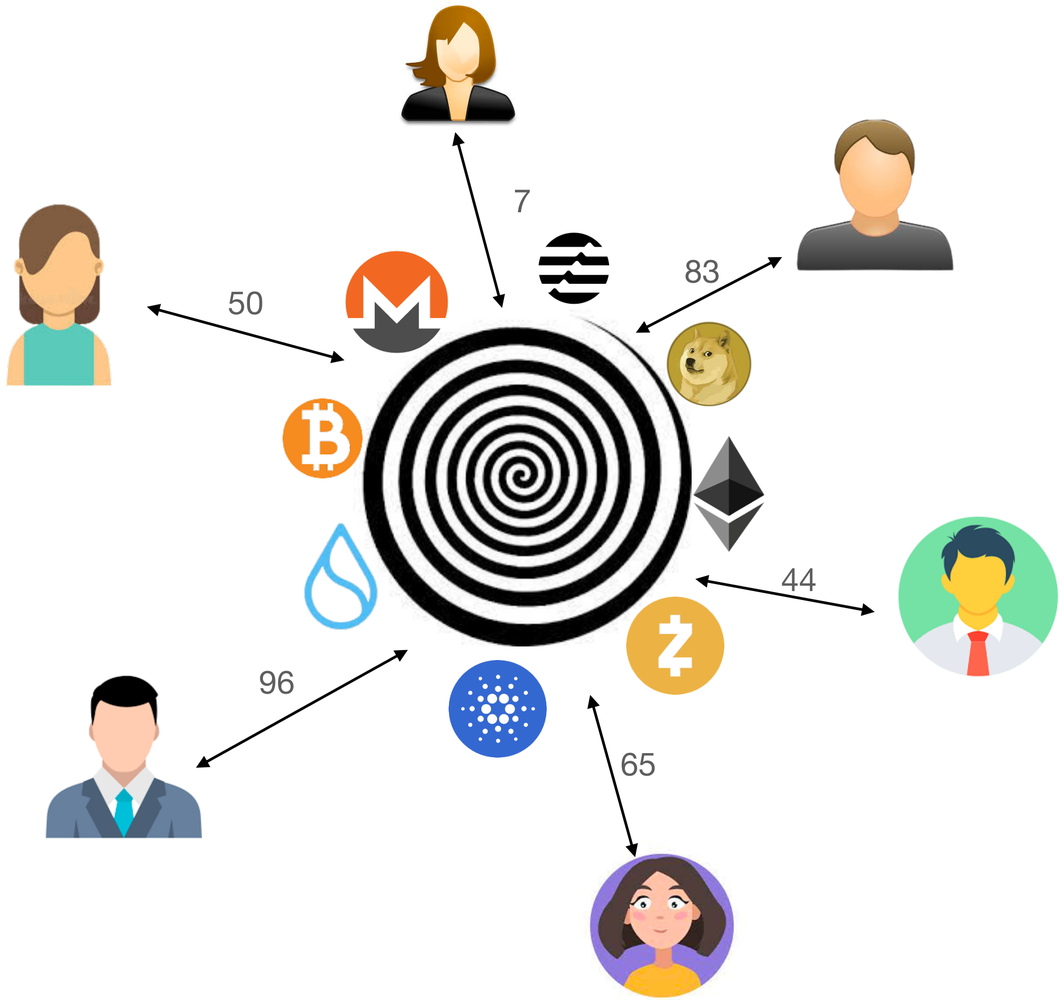


PCH with BlindChannel+Atomicity+Privacy+Griefing Resistance

Registration



PCH with BlindChannel+Atomicity+Privacy+Griefing Resistance = Blindhub



Performance

Role	Bandwidth (KB)	Comp. (ms)	Optimized Comp. (ms)
Sender	55843	8172	3083
Tumbler	87855	16245	8160
Receiver	32017	9063	6067

Phase	Bandwidth (KB)	Comp. (ms)	Optimized Comp. (ms)
Register	55843	8172	594
Promise	87855	16245	5773
Solver	32017	9063	2267
Open	16357	2284	520
Total	87860	17239	9154

Comment and comparison

- Limitation of our work

Comment and comparison

- Limitation of our work
  - Not UC secure

Comment and comparison

- Limitation of our work
  - Not UC secure
  - …

Comment and comparison

- My comment to this line of work
  -

Comment and comparison

- My comment to this line of work
  - Heavily rely on the honesty of the hub

Comment and comparison

- My comment to this line of work
  - Heavily rely on the honesty of the hub
    - Multiple hubs?

Comment and comparison

- My comment to this line of work
  - Heavily rely on the honesty of the hub
    - Multiple hubs?
  - K-anonymity

Comment and comparison

- Comparison

Comment and comparison

- Comparison
  - Tornado Cash
    - Payee can withdraw the coins whenever she wants (no time limits)
    - Rely on Turing-complete blockchain

Comment and comparison

- Comparison
  - Tornado Cash
    - Payee can withdraw the coins whenever she wants (no time limits)
    - Rely on Turing-complete blockchain
  - RGB
    - More Private, without relying on hub
    - Could not support Bitcoin itself

Future

- Compliance
  - Accountable Privacy
    - Example (paper) :
      - UTT (https://eprint.iacr.org/2022/452.pdf)
      - Pisces (https://eprint.iacr.org/2023/1317.pdf)

Thank you!

Full Version: https://eprint.iacr.org/2022/1735.pdf
Email: xrqin@cs.hku.hk