On Non-Uniform Security for Black-box Non-Interactive CCA Commitments

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NTT Research

Date: Apr 26, 2023

Commitments

Commitments

ALICE

BOB

Commitments

ALICE

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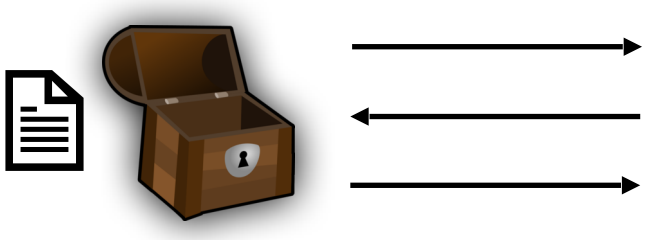
Commitments

ALICE



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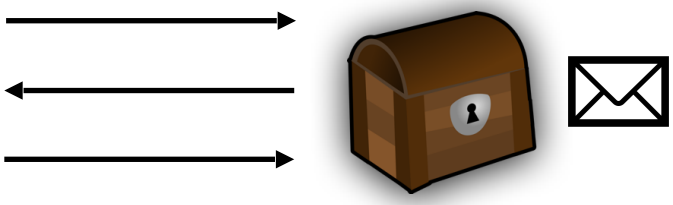

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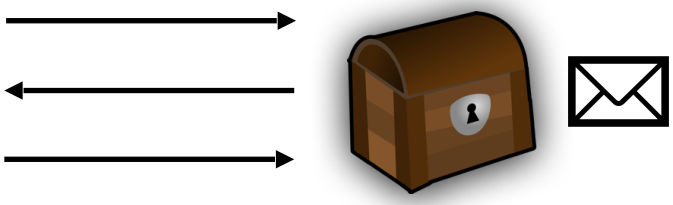

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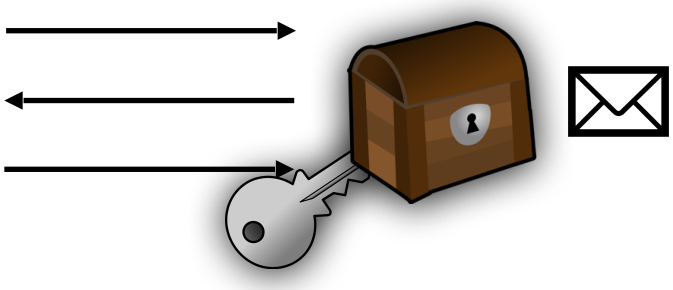

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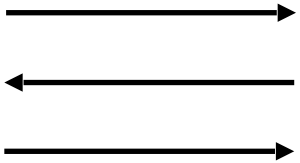

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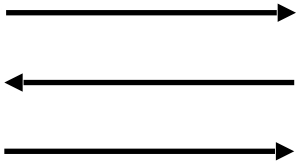

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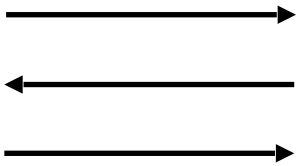

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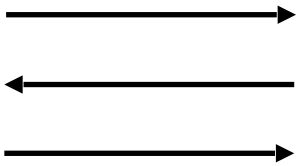

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Binding

Commitments

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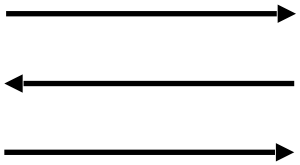

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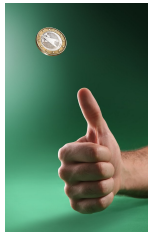

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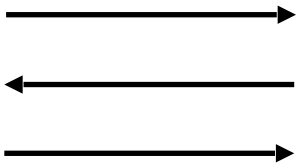

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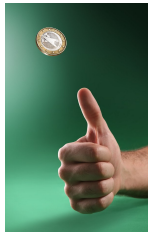

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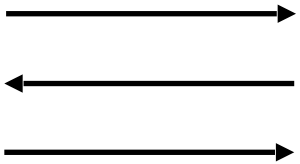

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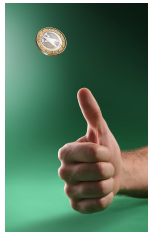

Auctions

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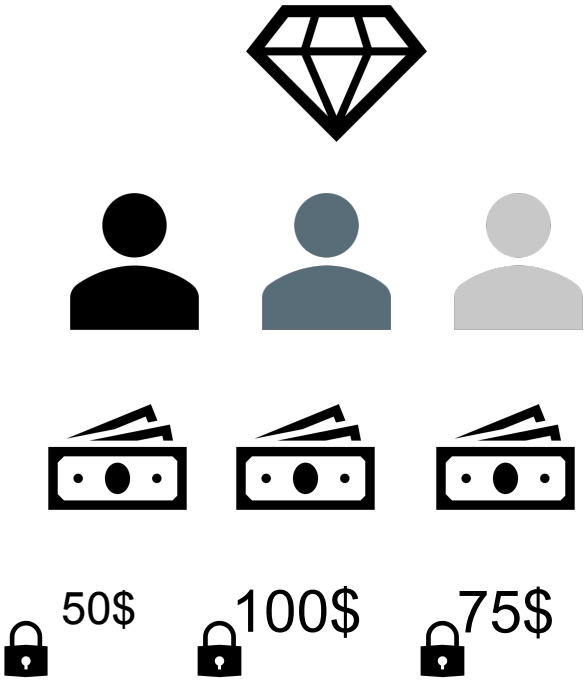

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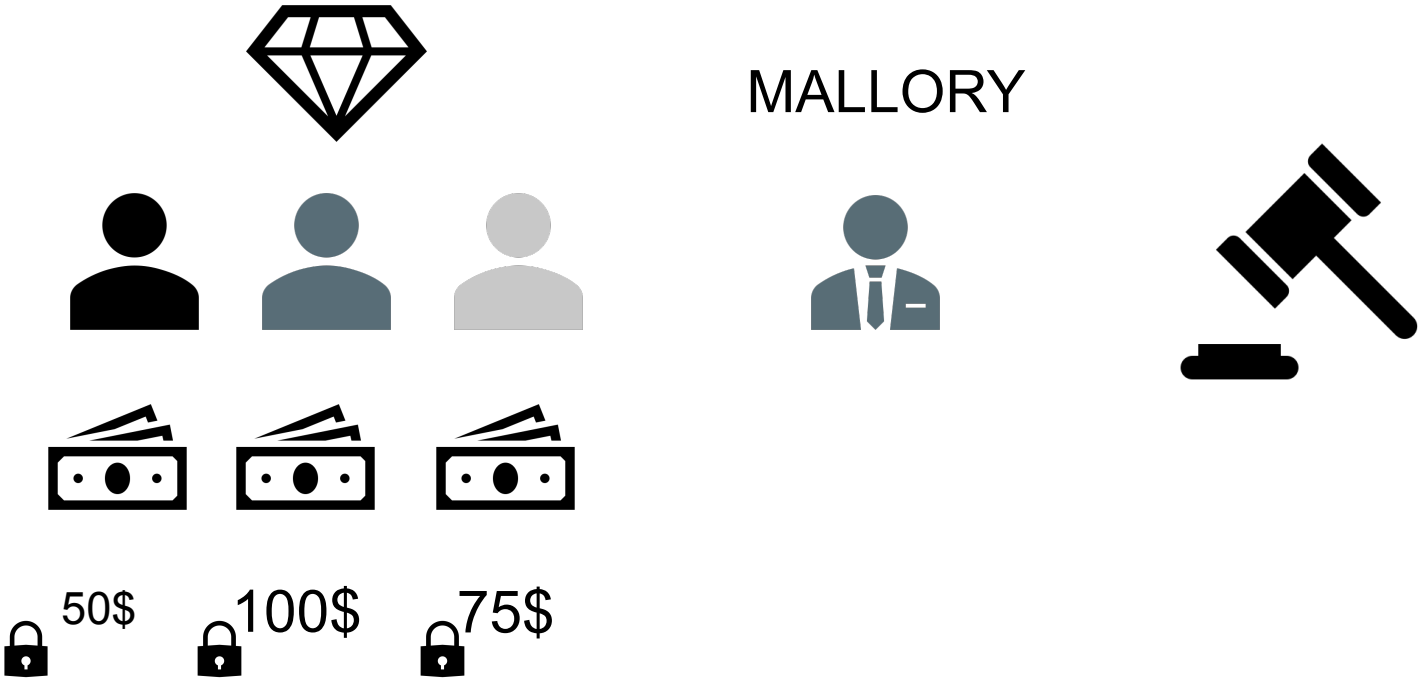

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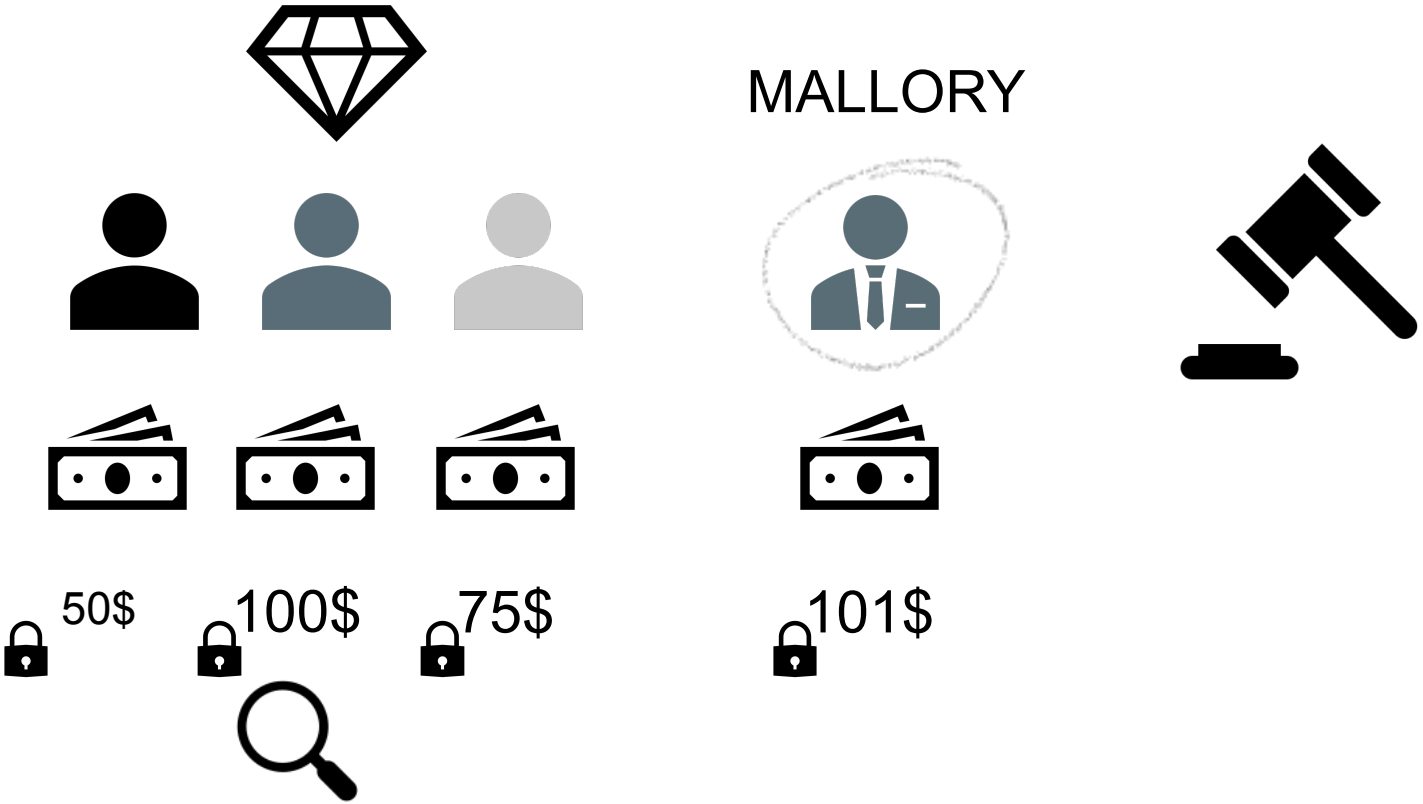

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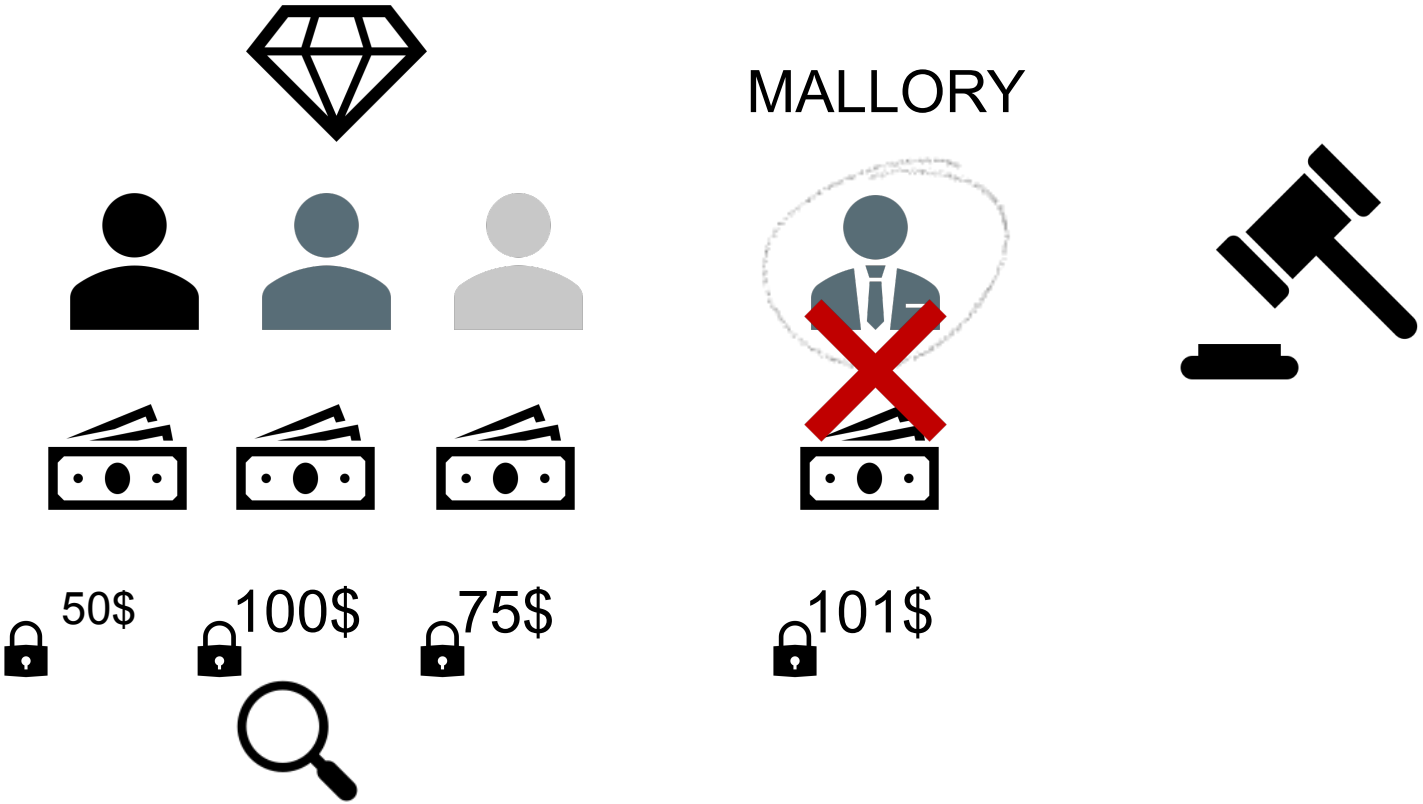

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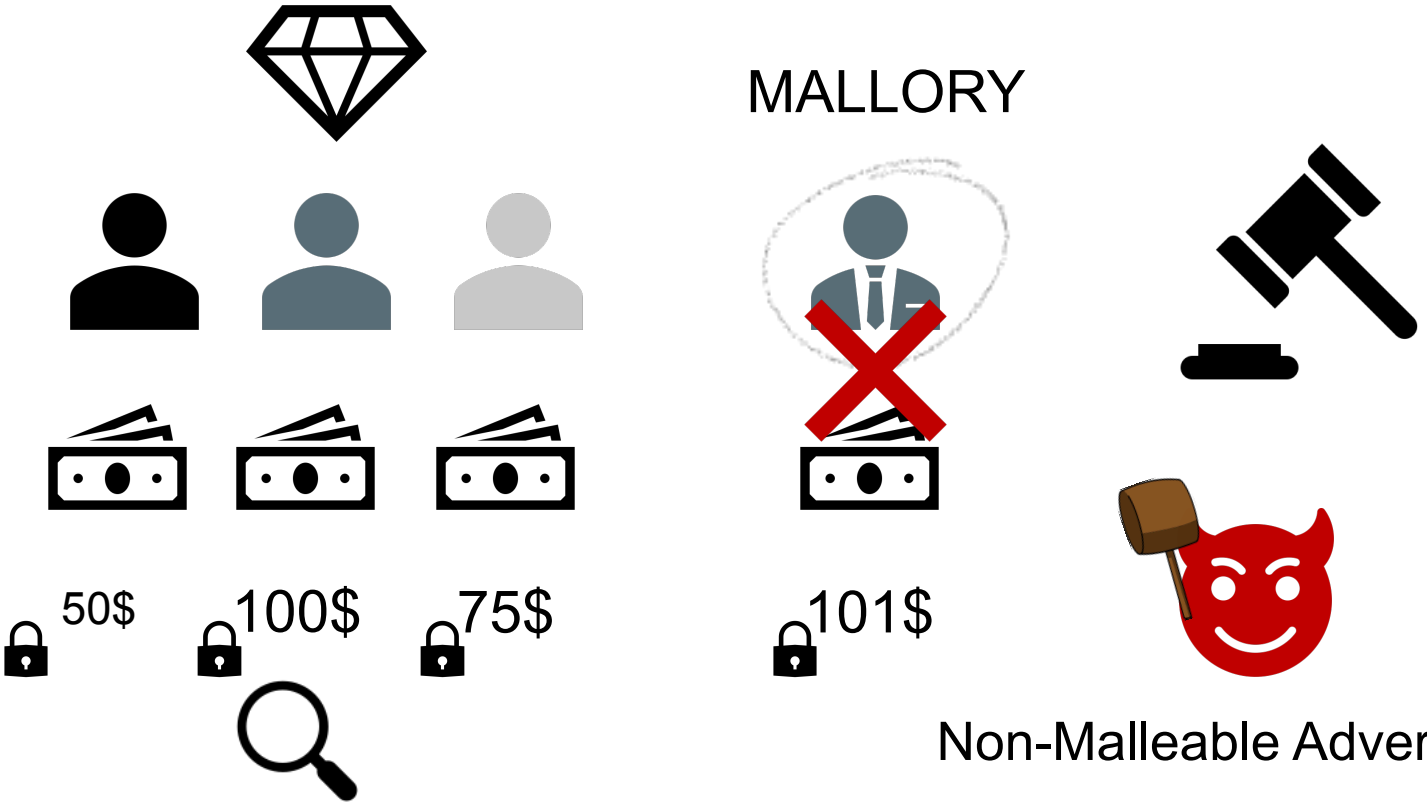
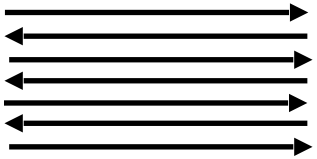


Non-Malleable Adversaries

NMC in literature

NMC in literature

$O(\log n)$



OWF

[DDN91]

NMC in literature

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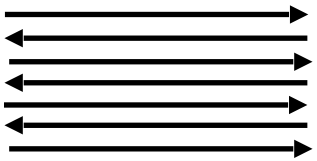

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[Bar02, Pas04, PR05, LPV08, Wee10, LP11, Goy11, GLOV12, GRRV14, GPR16, COSV17]

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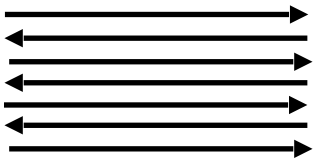

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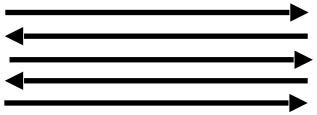
[DDN91]

3



[COSV16, Khu17, GR19]

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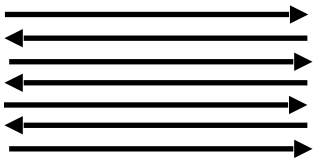

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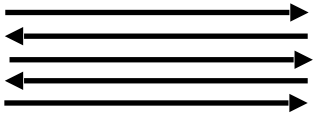
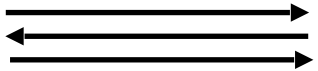


[COSV16, Khu17, GR19]

2



[LPS17, KS17]

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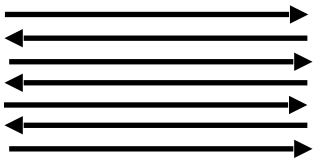

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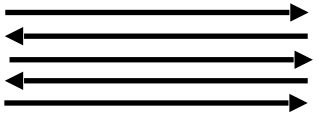

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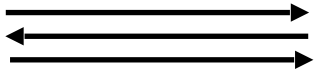

[LPS17, KS17]

Non-Interactive
Without Setup!

1

[PPV08, LPS17, BL18, KK19]

Building NMC

Building NMC

Cryptography
Assumptions

Building NMC

Cryptography Assumptions $\longrightarrow$ Tagged Commitments

Building NMC

Cryptography Assumptions $\longrightarrow$ Tagged Commitments $\rightleftharpoons$ NMC Commitments

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Building NMC

Cryptography Assumptions $\longrightarrow$ Tagged Commitments $\overset{*}{\rightleftharpoons}$ NMC Commitments

$*$

- One time signature scheme
- **Exponentially many tags**

Tagged Commitments

Tagged Commitments

$$c \leftarrow \mathsf{Com}(1^\lambda, tag, m; r)$$

$$\{m, \perp\} \leftarrow \mathsf{Open}(tag, c, m; r)$$

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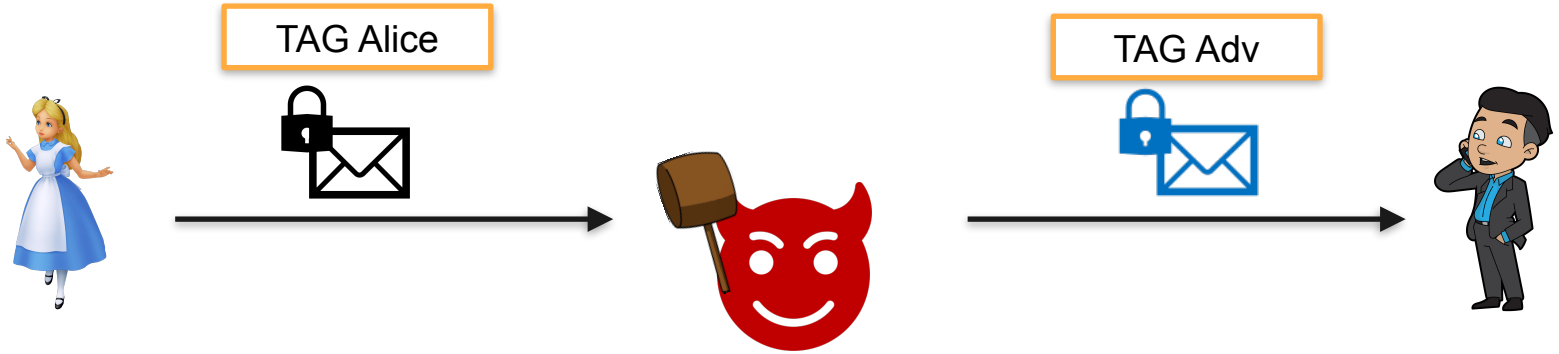

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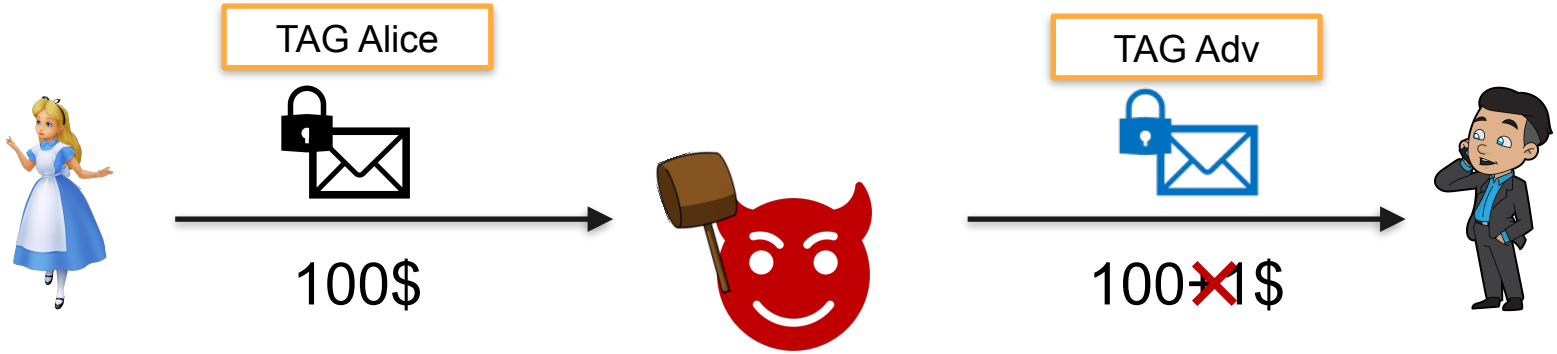

Tagged Commitments

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Perfect Binding

TAG Alice

100$

$\mathsf{Com}(tag, m; r)$

TAG Adv

100~~→~~1$

$\mathsf{Com}(tag^*, m'; r')$

m' must not be related to m

TAG left $\neq$ TAG right

Building NI tagged commitments

PPV08, LPS17, BL18, KK19

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PPV08, LPS17, BL18, KK19

[KK19] Subexponential Quantum-secure and quantum-insecure commitments
[BL18] Hardness-amplifiable one-way functions
[LPS17] Assuming subexponential time lock puzzles

$c \log \log \lambda$ tags

Building NI tagged commitments

PPV08, LPS17, BL18, KK19

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$c \log \log \lambda$ tags

Tag Amplification

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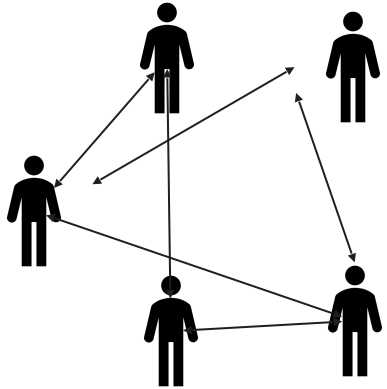

2^{λ} tags

Tag Amplification

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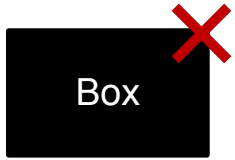

NIWIs iO

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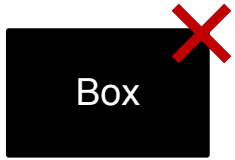

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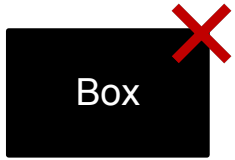

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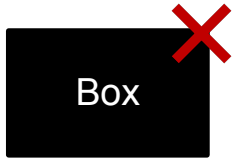

NIWIs iO

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Box

NIWIs

iO

Uniform Adversaries

Our landscape

Our landscape

Non-Uniform Adversaries

Our landscape

Non-Uniform Adversaries

1. Stronger class of adversaries, better composition for MPC protocols.

Our landscape

Non-Uniform Adversaries

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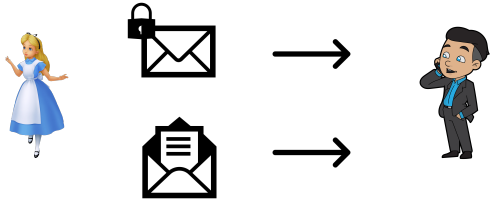
Our landscape

Non-Interactive



Black Box Access

No Setup

No CRS
No Random Oracle

Non-Uniform Adversaries

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Our Result

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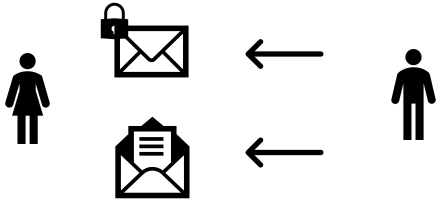
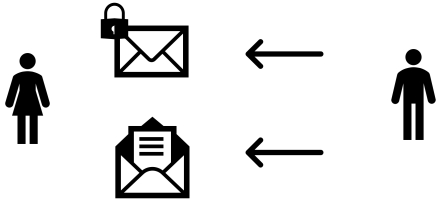
Non-Interactive



Non-Malleable

Our Result

Non-Interactive

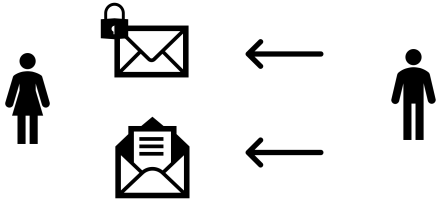


Non-Malleable

$c \log \log \lambda$ tags $\longrightarrow$ 2^{λ} tags

Our Result

Non-Interactive



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ADVICE

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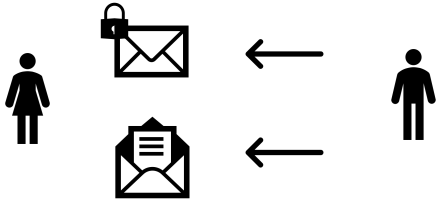

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ADVICE

Box

NIZKs ~~iO~~

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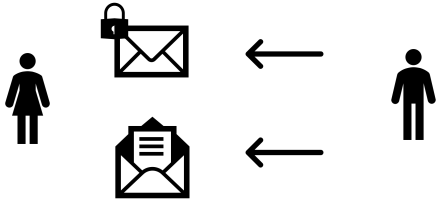


Non-Malleable

$c \log \log \lambda$ tags $\longrightarrow$ 2^{λ} tags

ADVICE

Consistency Checks

Box

NIZKs ~~iO~~

CCA Hiding

CLP10 (FOCS’10)

CCA Hiding

$\mathsf{Val}(tag, c)$

CLP10 (FOCS'10)

CCA Hiding

$\mathsf{Val}(tag, c)$

Brute force open

CLP10 (FOCS'10)

CCA Hiding

$\xleftarrow{\quad tag^* \quad}$

$\mathsf{Val}(tag, c)$

Brute force open

CLP10 (FOCS'10)

CCA Hiding

tag^*

$\mathsf{Val}(tag, c)$

Brute force open

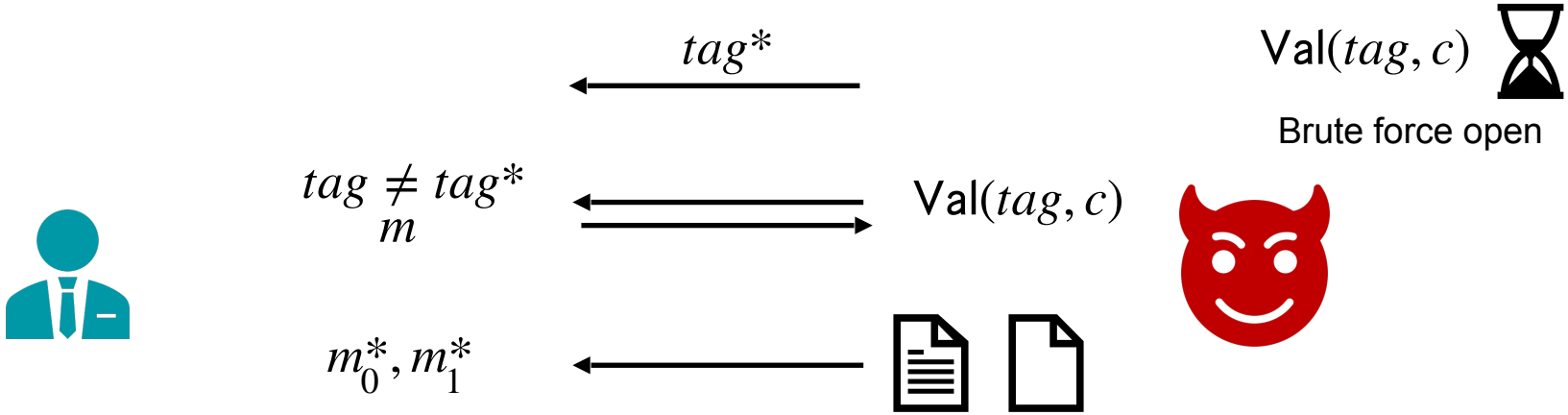
$tag \neq tag^*$

m

$\mathsf{Val}(tag, c)$

CLP10 (FOCS'10)

CCA Hiding



CLP10 (FOCS'10)

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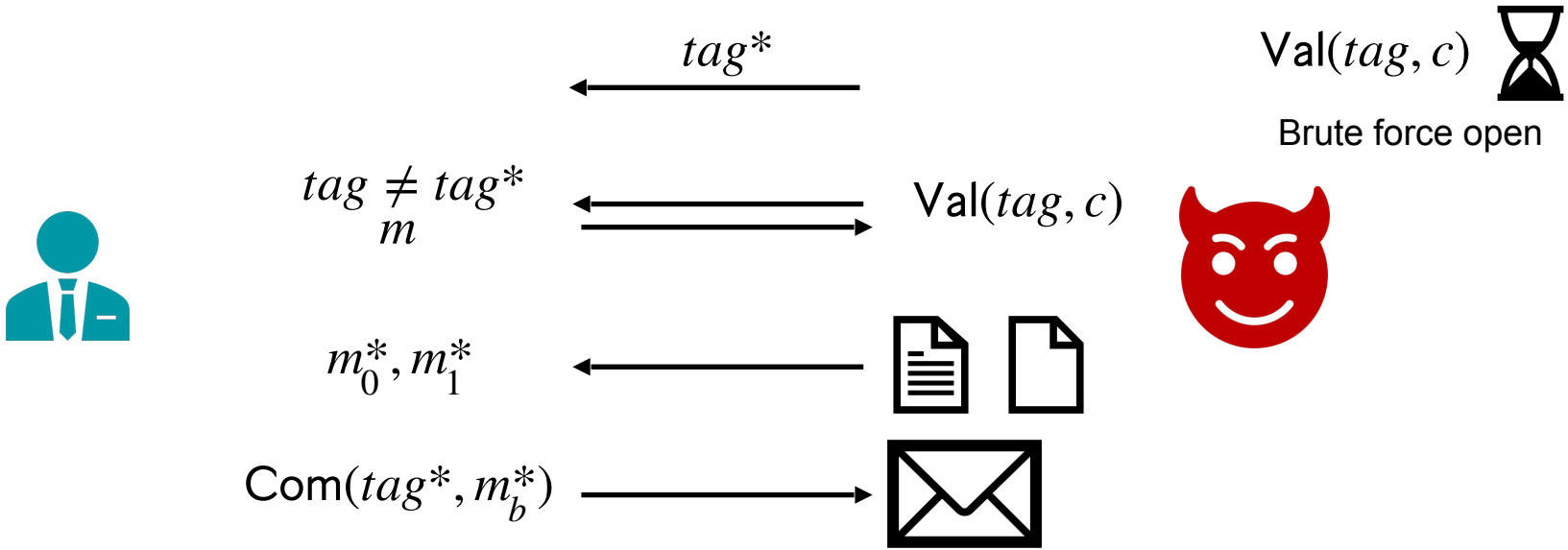

CLP10 (FOCS'10)

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Brute force open

tag^*

$tag \neq tag^*$

m

$\mathsf{Val}(tag, c)$

m_0^*, m_1^*

$\mathsf{Com}(tag^*, m_b^*)$

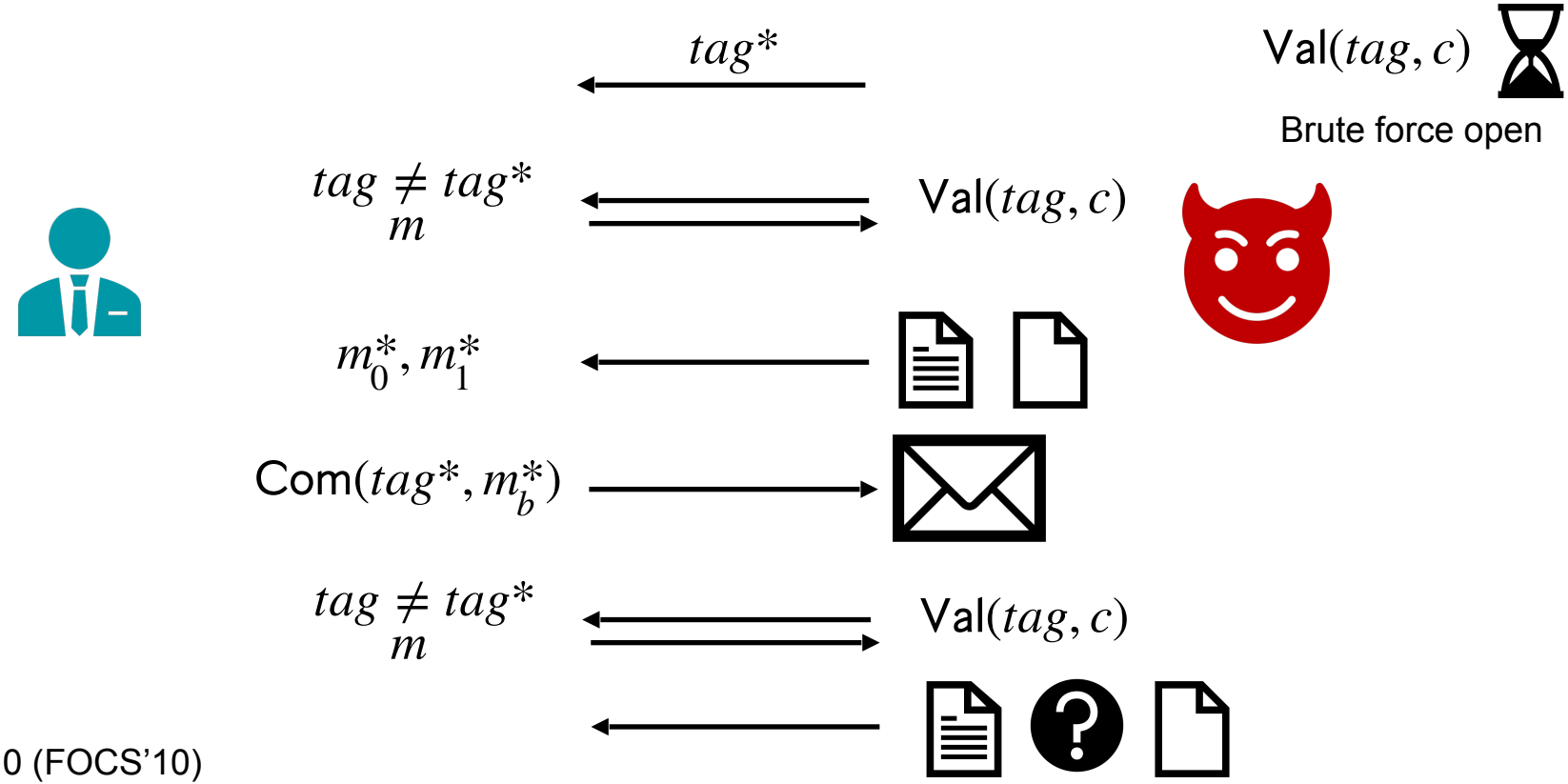
$tag \neq tag^*$

m

$\mathsf{Val}(tag, c)$

CLP10 (FOCS'10)

CCA Hiding



CLP10 (FOCS'10)

Tag Amplification

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$$\log\log\lambda \to \log\lambda \to \lambda \to 2^{\lambda}$$

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$\mathsf{Com}(TAG, m)$

$TAG = 11011 \in \{0,1\}^5$

$\mathsf{Com}(tag, m)$

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Proof of consistency

Tag Amplification

$\mathsf{Com}(TAG, m)$

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Proof of consistency

$\mathsf{Val}(TAG, c)$ ⌛

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Proof of consistency

$\mathsf{Val}(TAG, c)$ ⌛

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Tag Amplification

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Proof of consistency

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$TAG \neq TAG^*$

Tag Amplification

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Tag Amplification [GKLW21]

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Hybrid 0 - CCA game on big TAG

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Tag Amplification [GKLW21]

Consistency Check

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Consistency Check
Security of CHRFs

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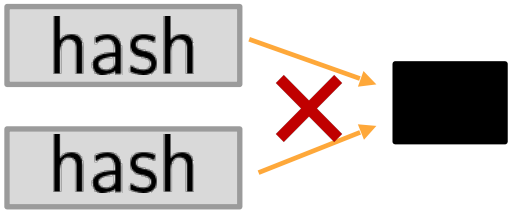
Keyless CRHFs - SHA256



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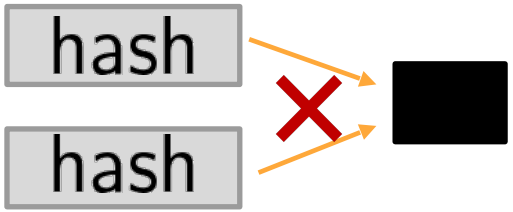

Uniform Adversaries

Non-Uniform Keyless CRHFs [BKP18,BL18]

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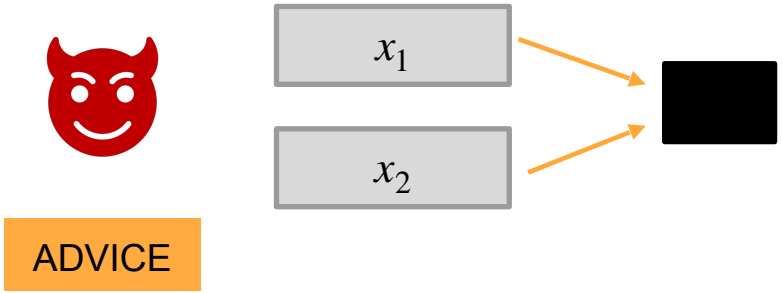

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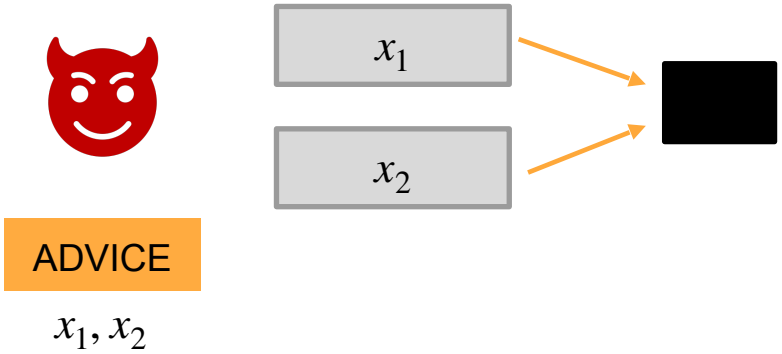

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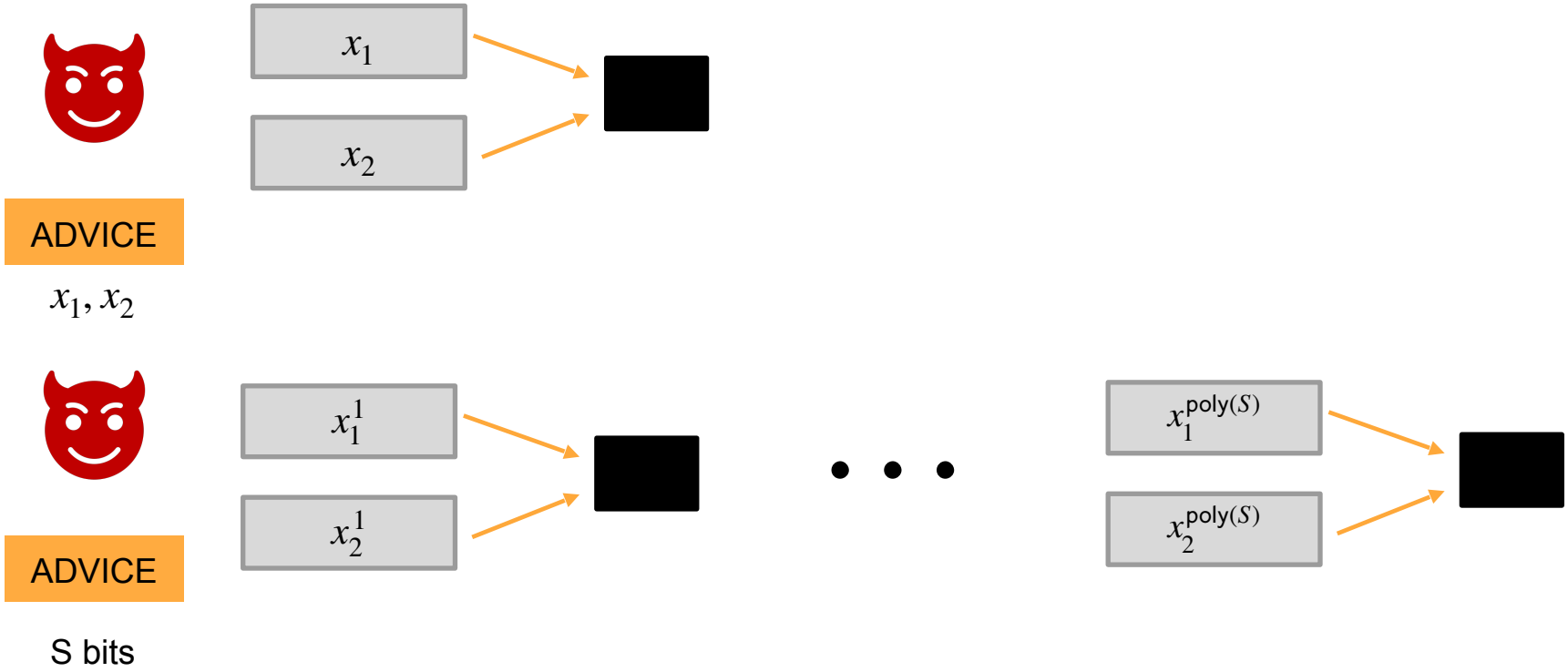

Reduction [GKLW21]

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$$\mathsf{Val}(TAG, c^*) \neq \mathsf{Val}^*(TAG, c^*)$$

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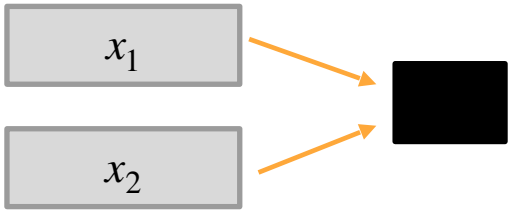

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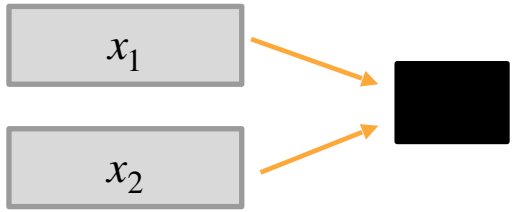

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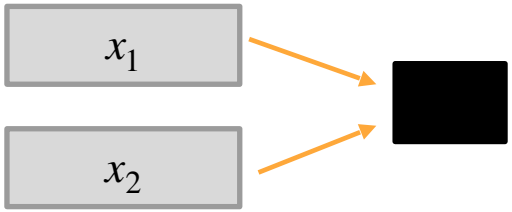

ADVICE

Can find a collision!

Reduction Idea

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ADVICE

Special Commitment c_1^*

• • •

ADVICE

Special Commitment $c^*_{\mathsf{poly(S)}}$

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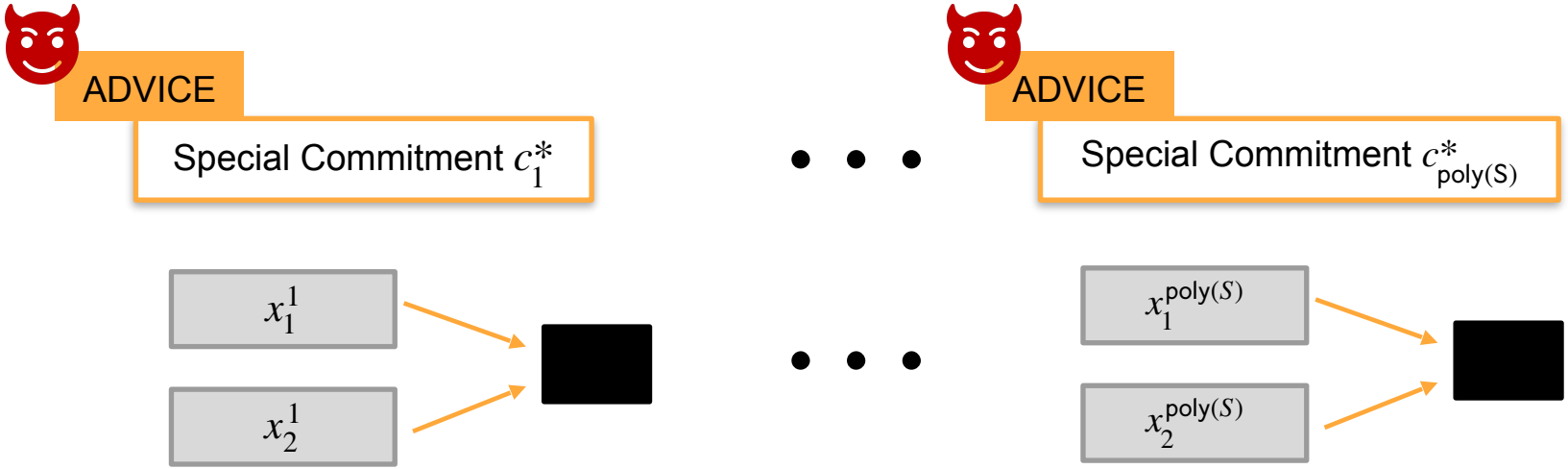

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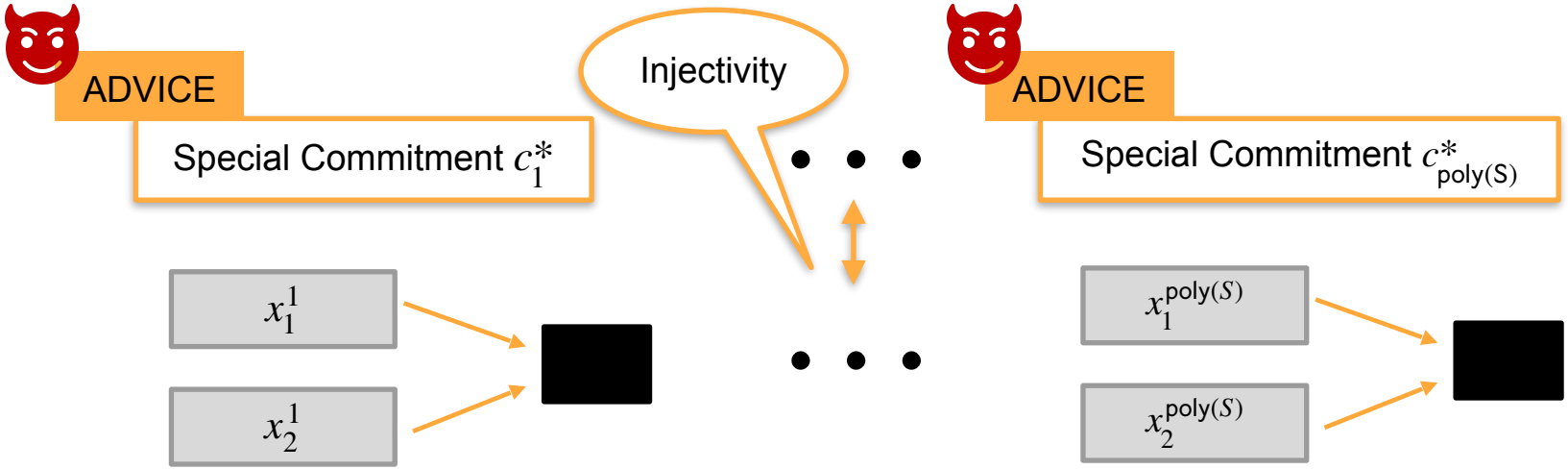

Ingredients

Ingredients

GKLW21

Hinting PRGs [KW19]

Keyless CRHFs

Ingredients

GKLW21

Special PRG

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Ingredients

GKLW21

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Our Work

Ingredients

GKLW21

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Our Work

Hinting PRGs w injective extension

$s \rightarrow s'_1 \quad \cdots \quad s'_n$

$s \rightarrow s'_1 \quad \cdots \quad s'_n \quad s''$

s'' is injective with s

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CDH or LWE

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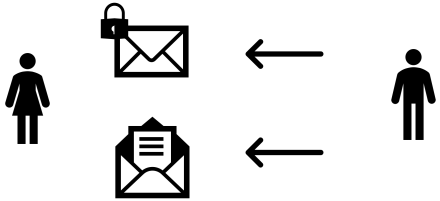
Keyless CRHFs can't find 2S collisions w S advice

CDH or LWE

Our Result

Our Result

Non-Interactive



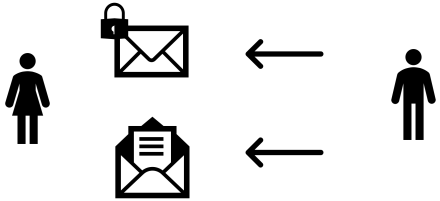
Non-Malleable

$c \log \log \lambda$ tags $\longrightarrow$ 2^{λ} tags

ADVICE

Our Result

Non-Interactive



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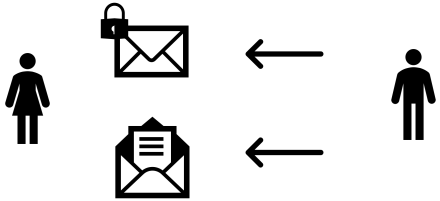

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Box

~~NIWIs~~ ~~iO~~

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Thanks!

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- [LPS17] Huijia Lin, Rafael Pass, and Pratik Soni. Two-round and non-interactive concurrent non-malleable commitments from time-lock puzzles. In *FOCS 2017*.

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