Four-Round Black-Box Non-Malleable Commitments from One-Way Permutations

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Danish Technical University

Commitment scheme

Commitment scheme

Commitment scheme

Commitment scheme

Commitment scheme

Commitment scheme

- Binding

Commitment scheme

- Binding
- Hiding

Non-malleable commitment

w.r.t. commitment

Man In the Middle

Non-malleable commitment

w.r.t. commitment

Man In the Middle

Non-malleable commitment

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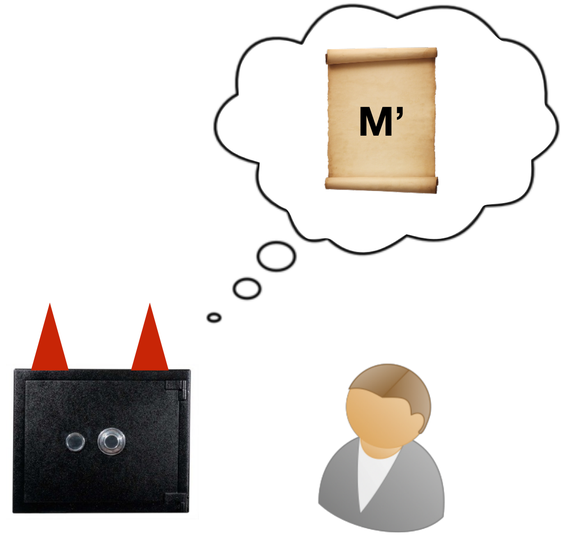
Man In the Middle



Non-malleable commitment

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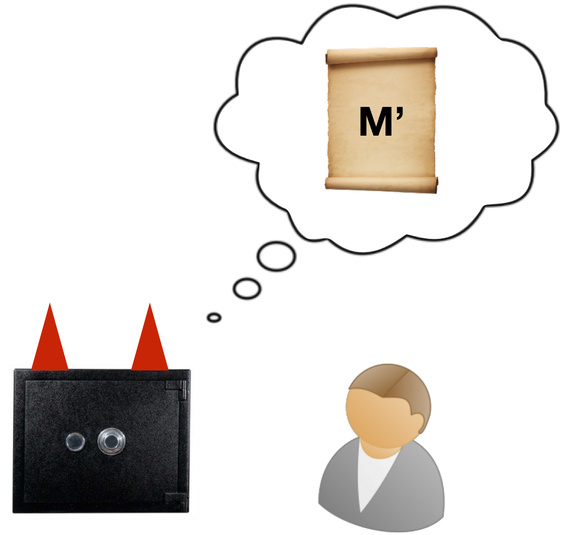


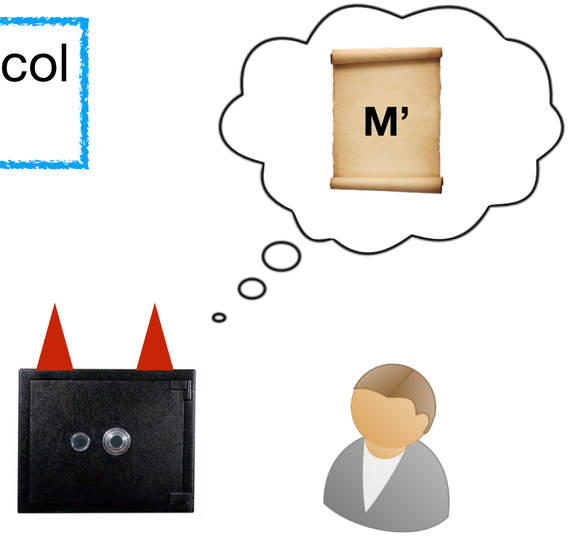
No relation between **M** and **M'**

Non-malleable commitment

w.r.t. commitment

Crucial for constructing MPC protocol with minimal round complexity

Man In the Middle



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State of the art on non-malleable commitments

(Plain model, polynomial-time assumptions)

*one-to-one OWFs

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Result	Number of rounds	Assumptions	BB use of adversary	BB use of primitives
[DDN, STOC91]	Logarithmic	OWFs	Yes	**No**
[Bar, FOCS02]	Constant	CHRFs + TPs	No	**No**
[PR, FOCS05]	Constant	Claw-Free Perm	No	**No**
[PW, EUROCRYPT10]	Constant	Sub-esponenial OWFs	Yes	**No**
[Goy11/LP11, STOC11]	Constant	OWFs	Yes	**No**
[GLOV, FOCS12]	Constant	BB OWFs	Yes	**Yes**

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[GRRV, FOCS14]	4	OWFs	Yes	**No**
[COSV, CRYPTO17]	4	OWFs*	Yes	**No**
[Khu, TCC17]	3	DDH	Yes	**No**
[GR19, FOCS19]	3	OWFs*	Yes	**No**

Three-round lower bound [Pas,TCC13]

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This work	**4**	**OWFs***	**Yes**	**Yes**

Three-round lower bound [Pas,TCC13]

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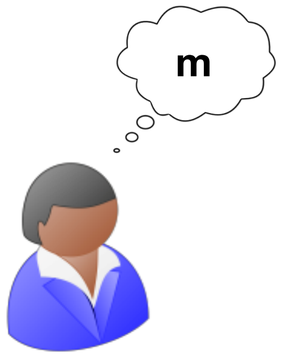
Weak Non-Malleable Commitments



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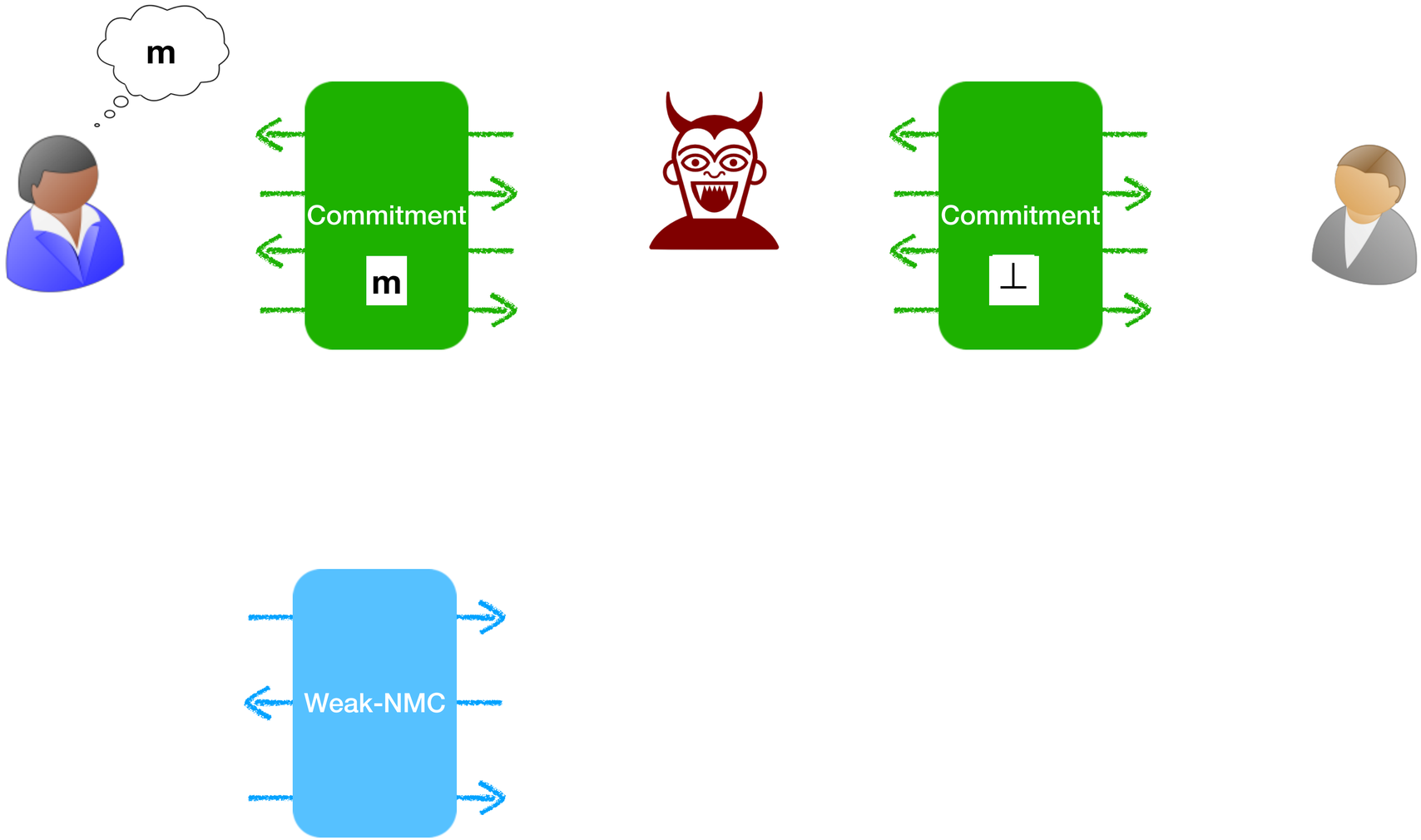
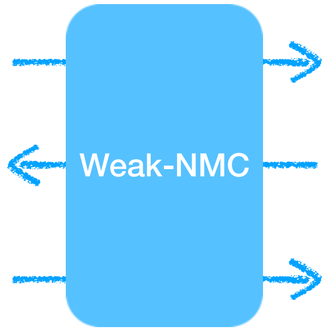


[GRRV14] Vipul Goyal, Silas Richelson, Alon Rosen, and Margarita Vald. FOCS 2014

Weak Non-Malleable Commitments



[GRRV14, Lemma] Weak-non-malleable commitment

Has an extractor

[GRRV14] Vipul Goyal, Silas Richelson, Alon Rosen, and Margarita Vald. FOCS 2014

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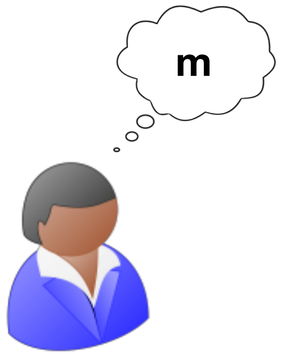
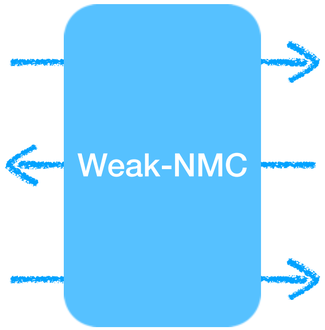


Weak MiM



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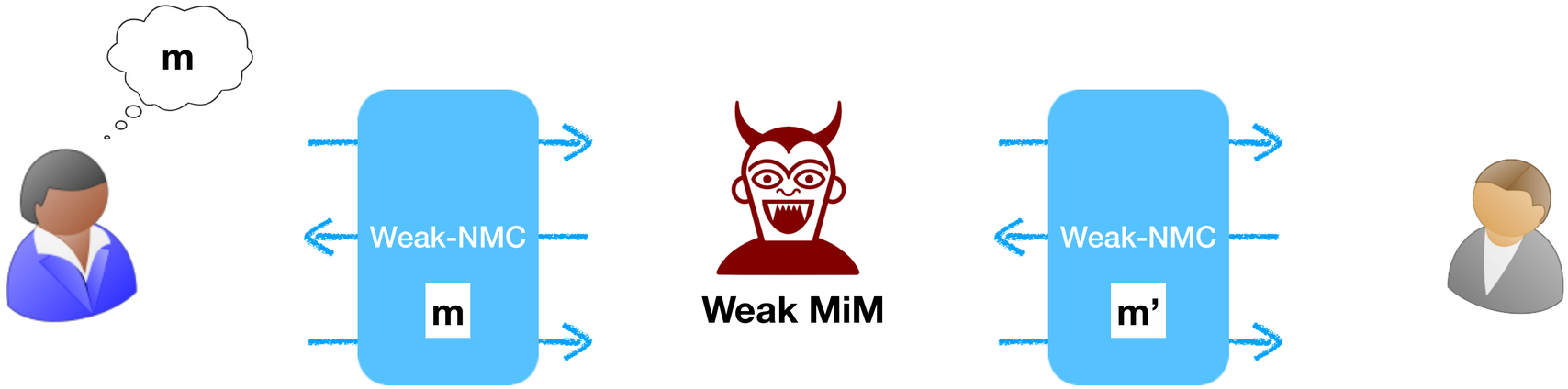

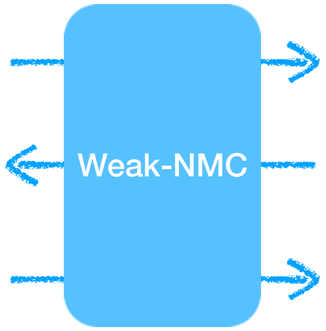

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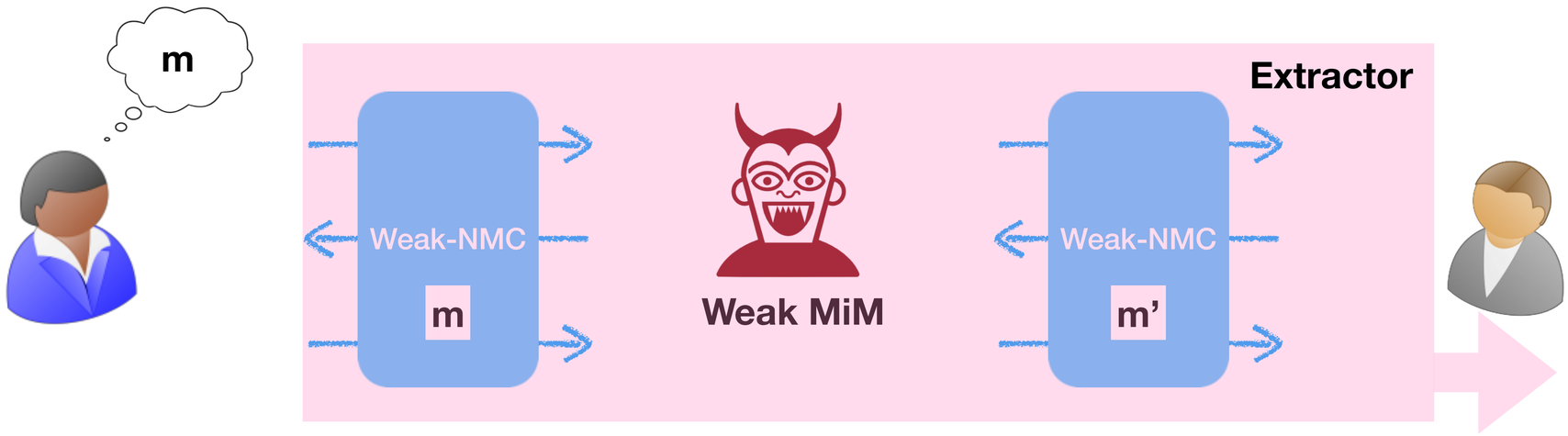

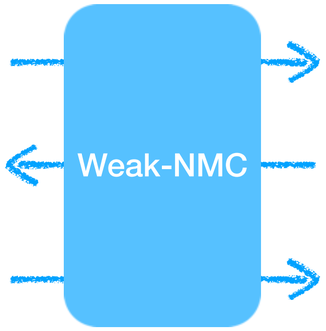

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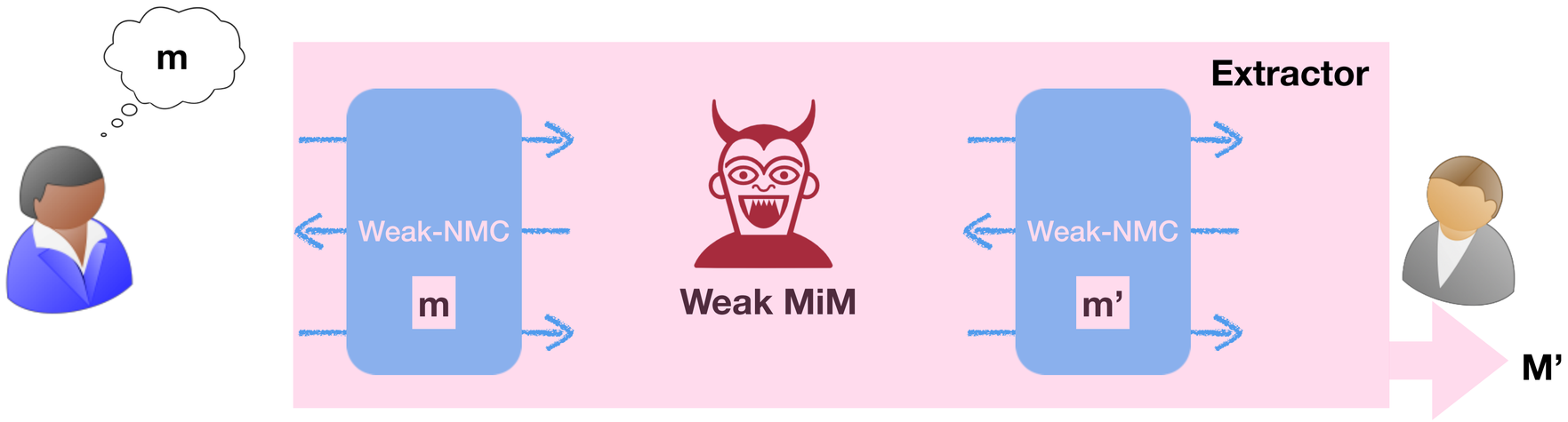

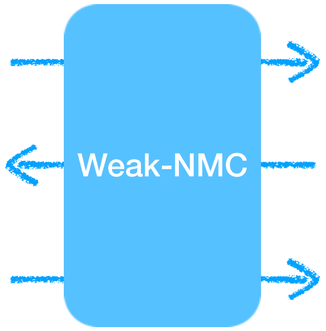

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A candidate approach

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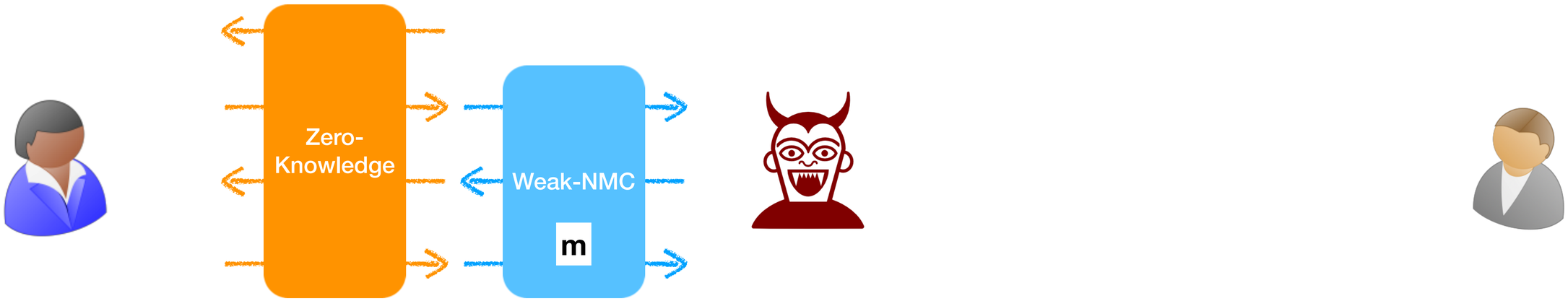

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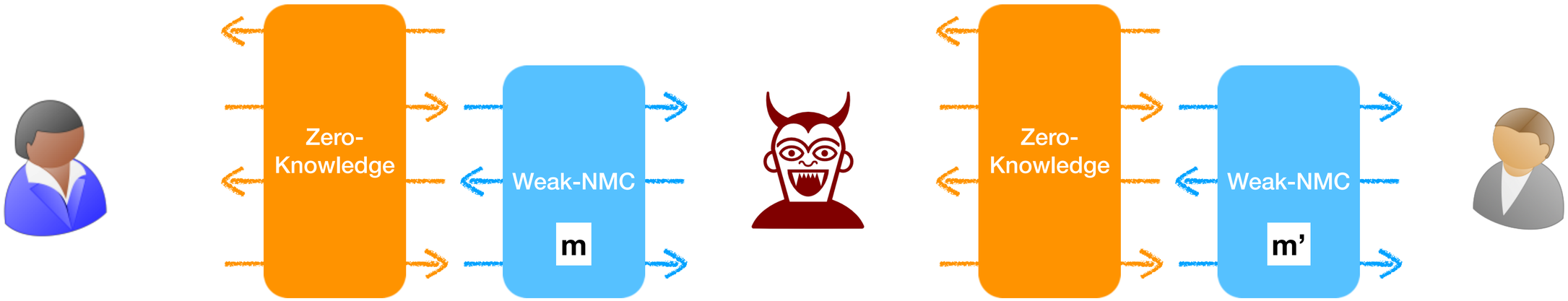

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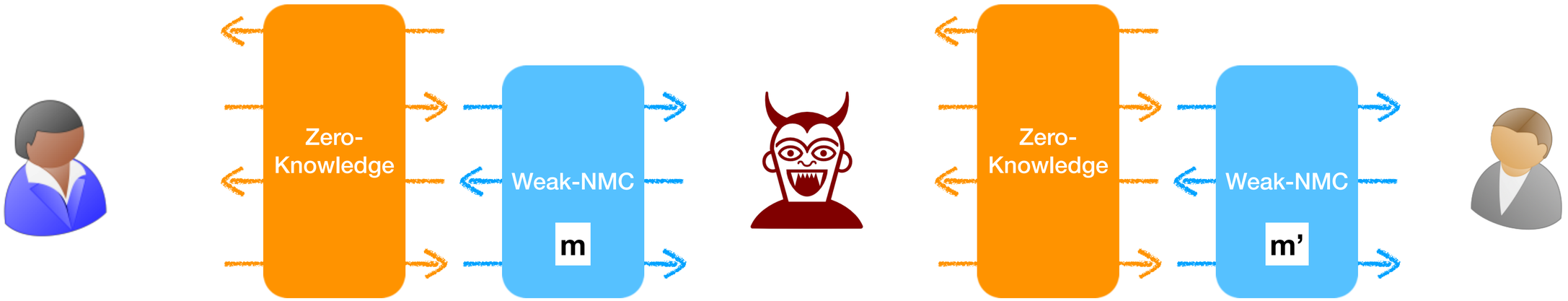

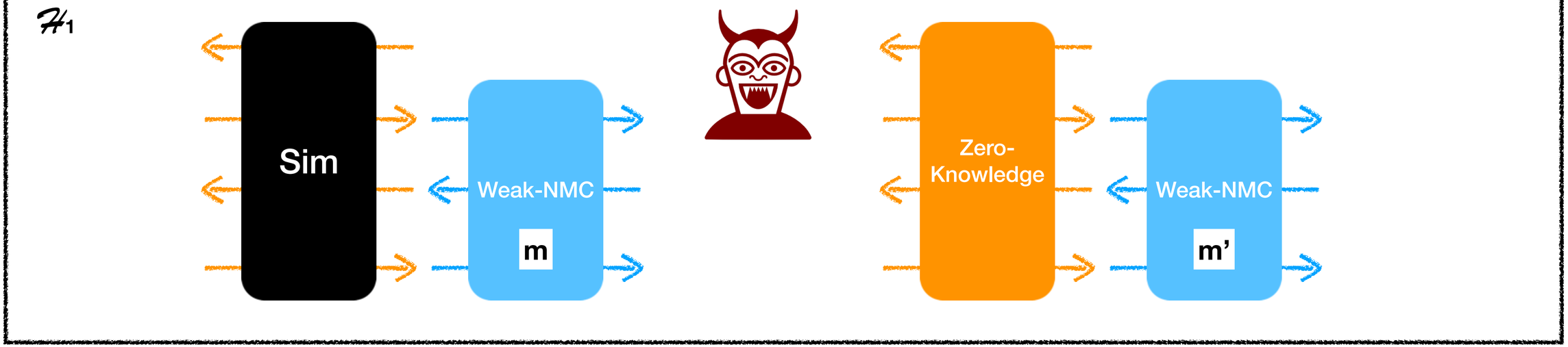

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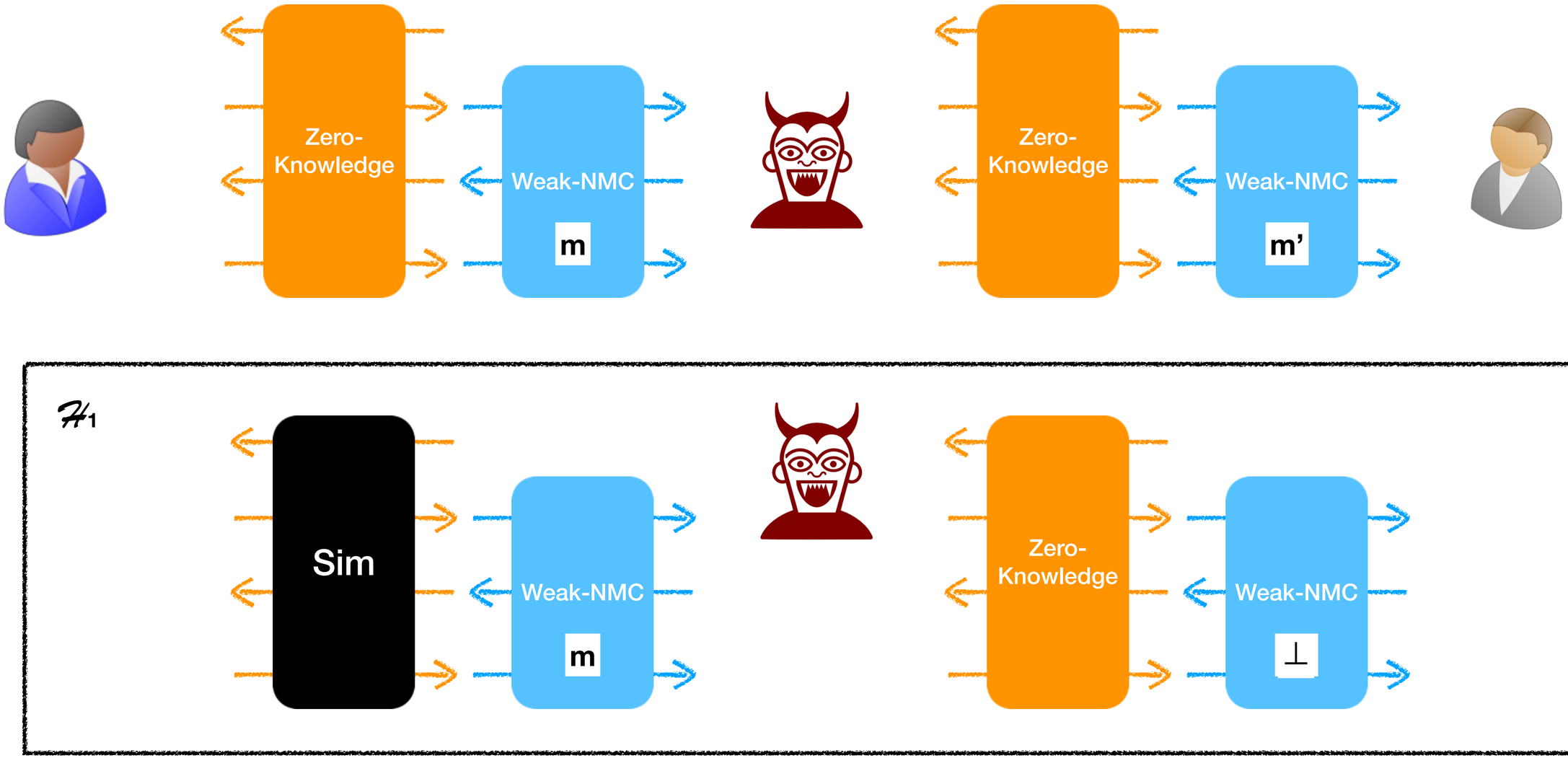

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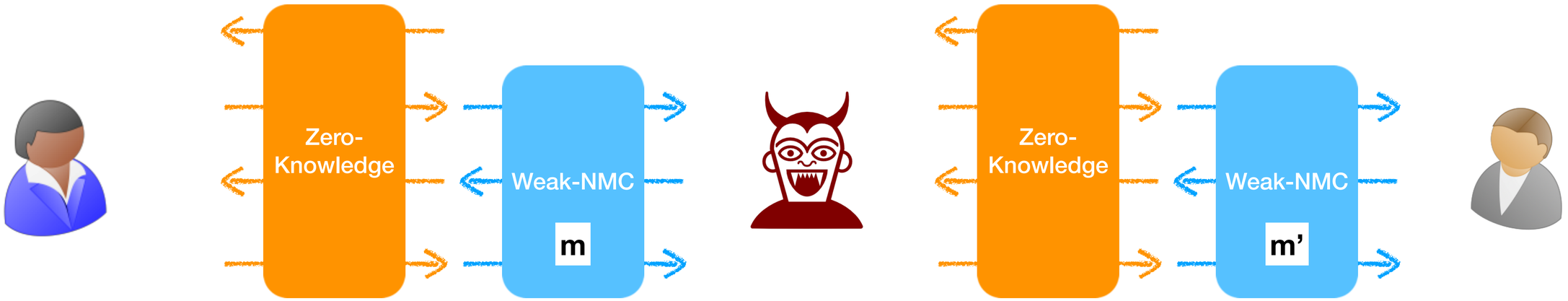

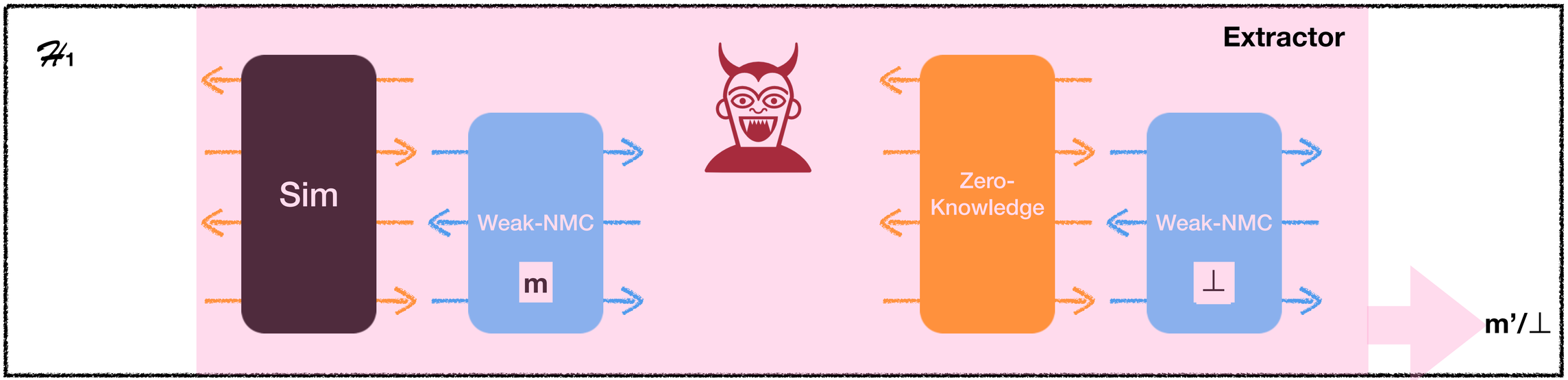

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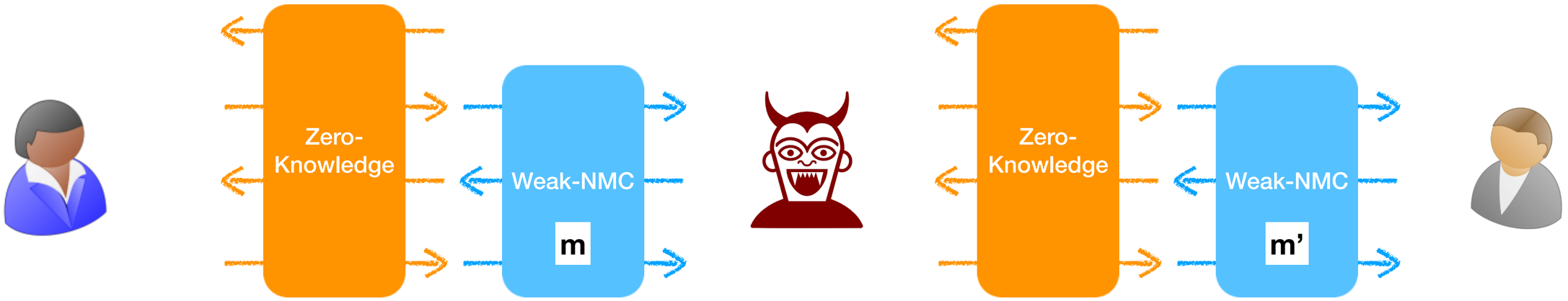

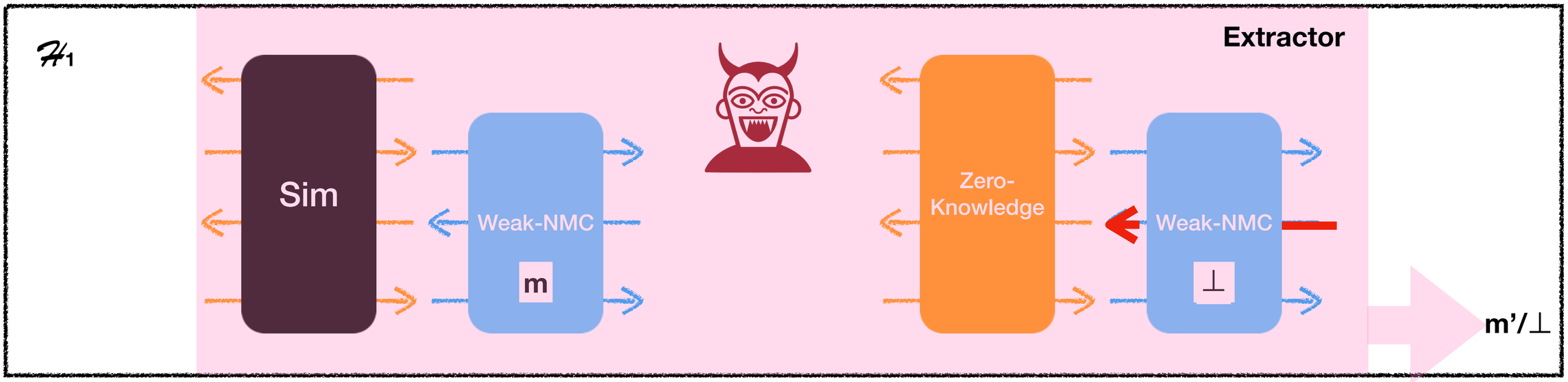

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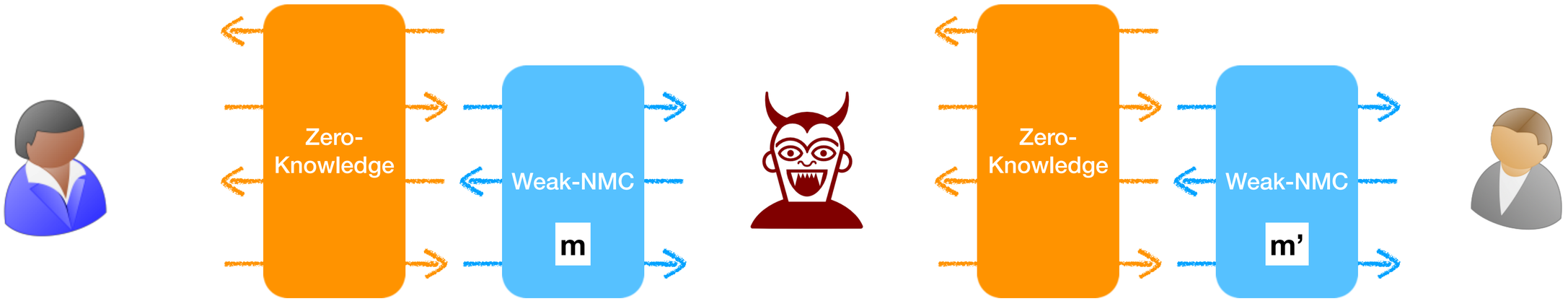

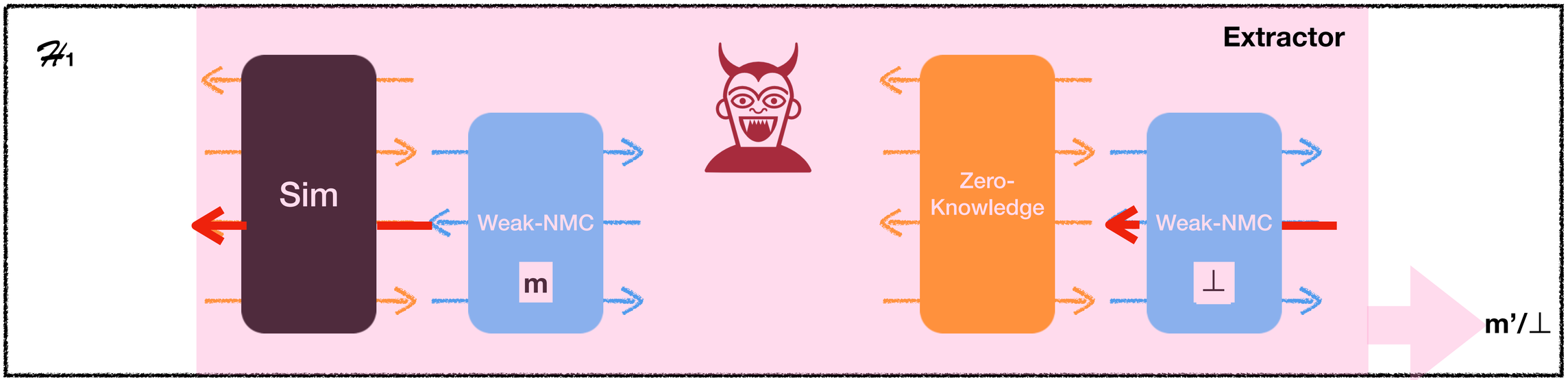

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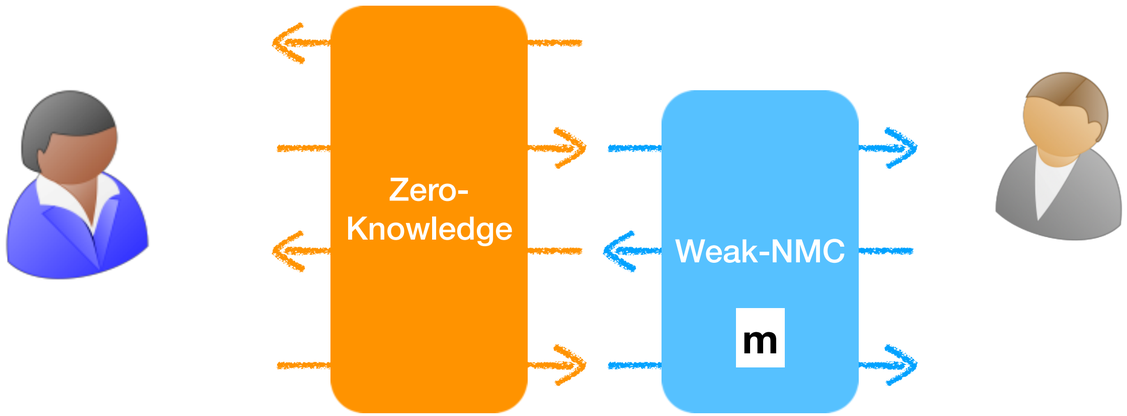

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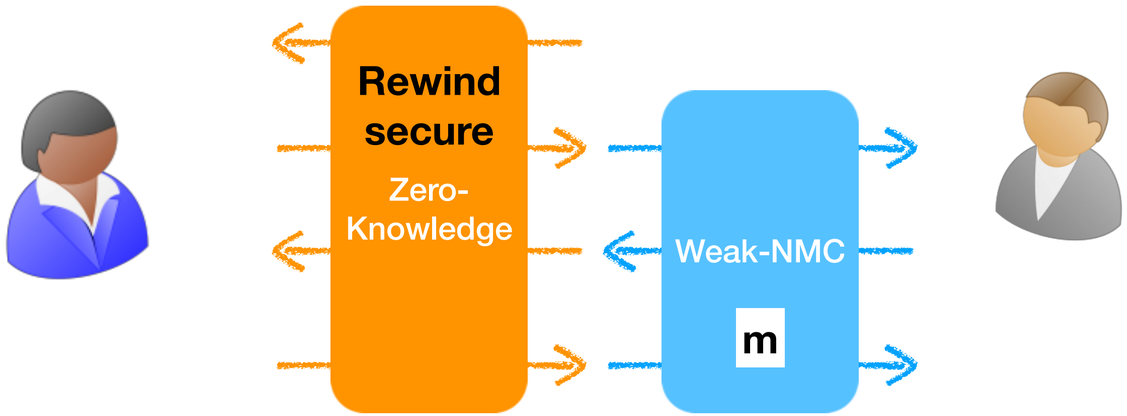

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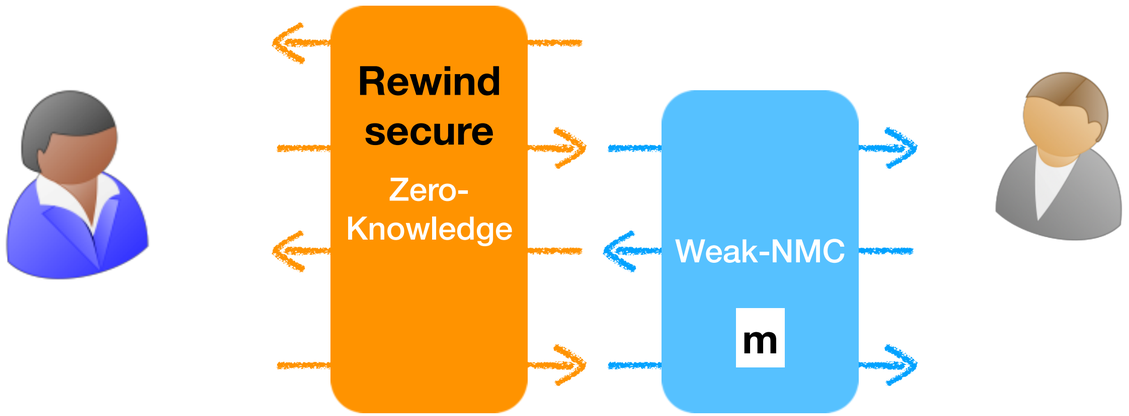

4-round non-malleable commitment

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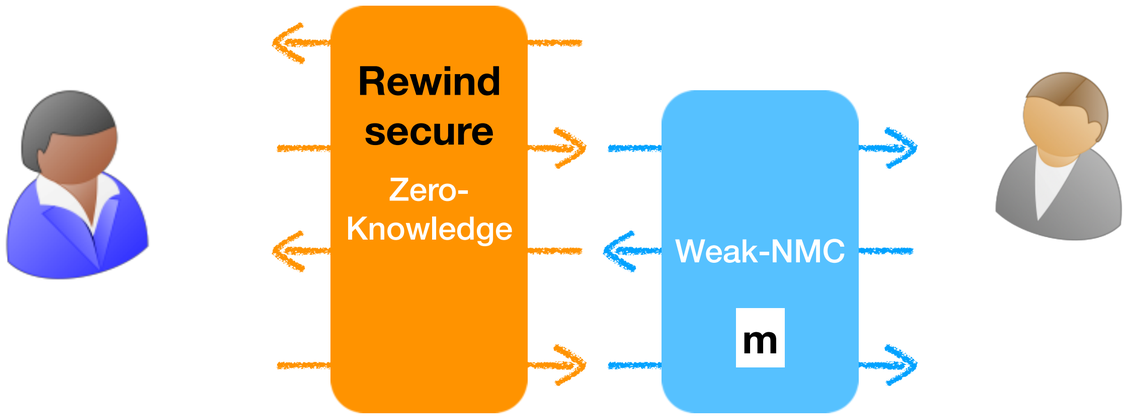

4-round non-malleable commitment

ZK is non-black box and it makes non-black-box use of the Weak-NMC

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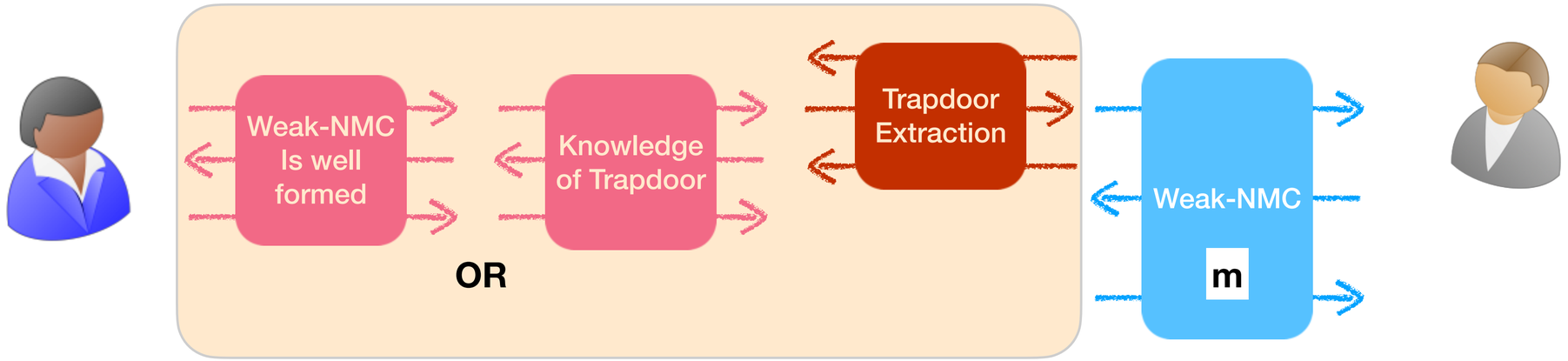
Our Approach



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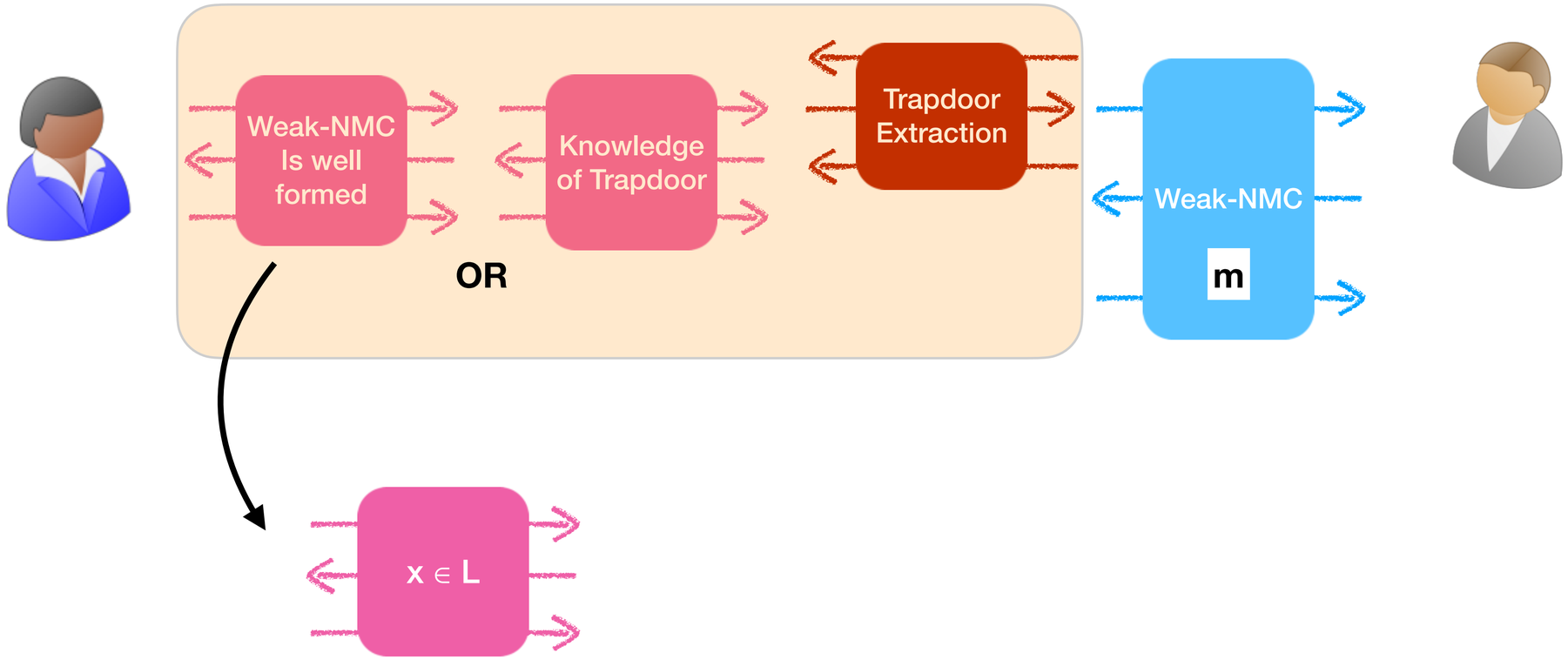

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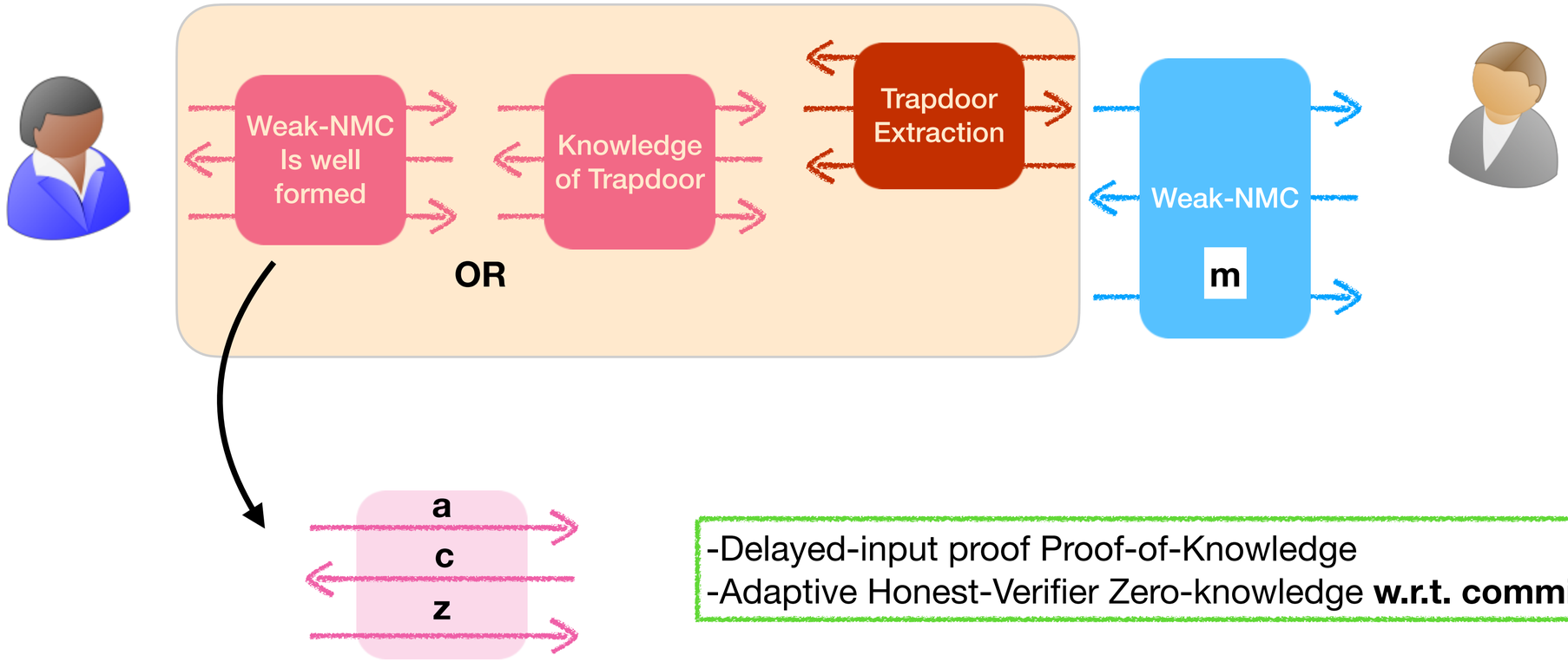

-Delayed-input proof Proof-of-Knowledge
-Adaptive Honest-Verifier Zero-knowledge **w.r.t. commitment**

Honest verifier zero-knowledge with respect to commitments (HVZK**C**)

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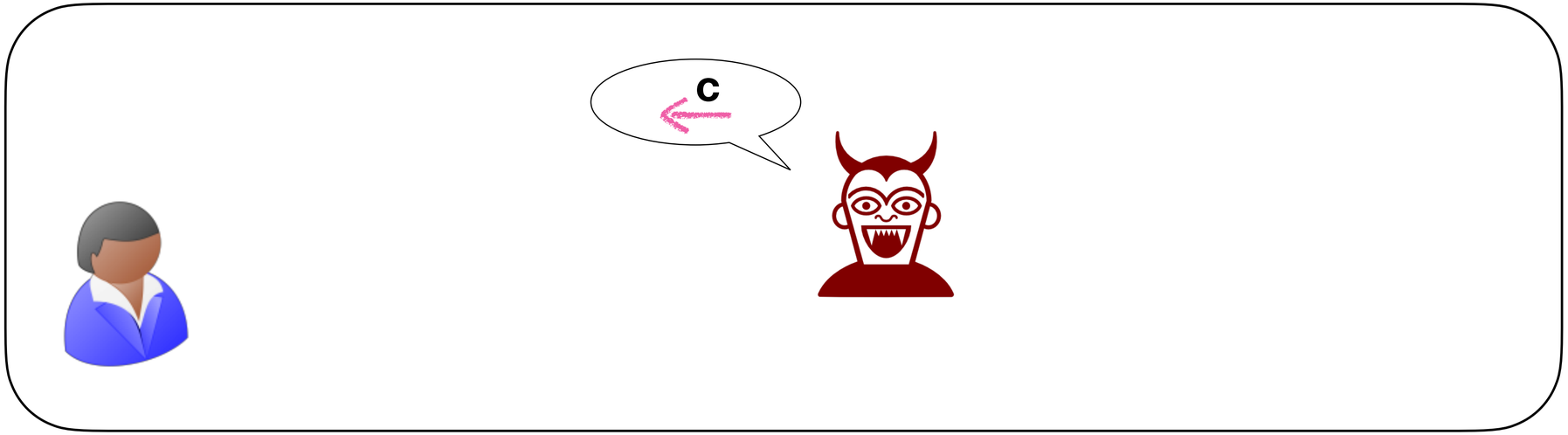

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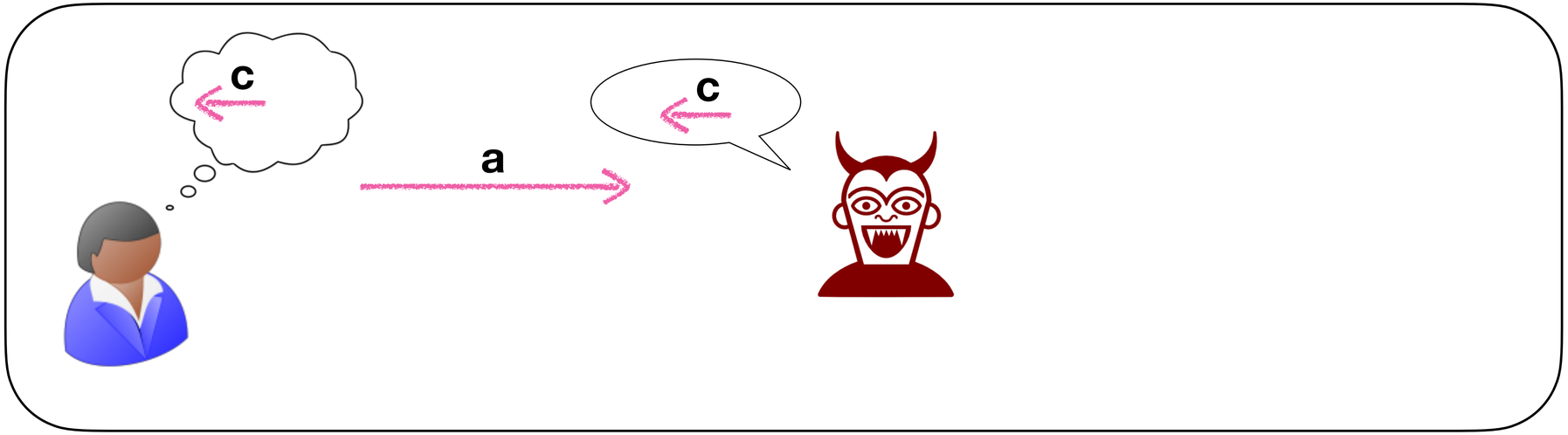

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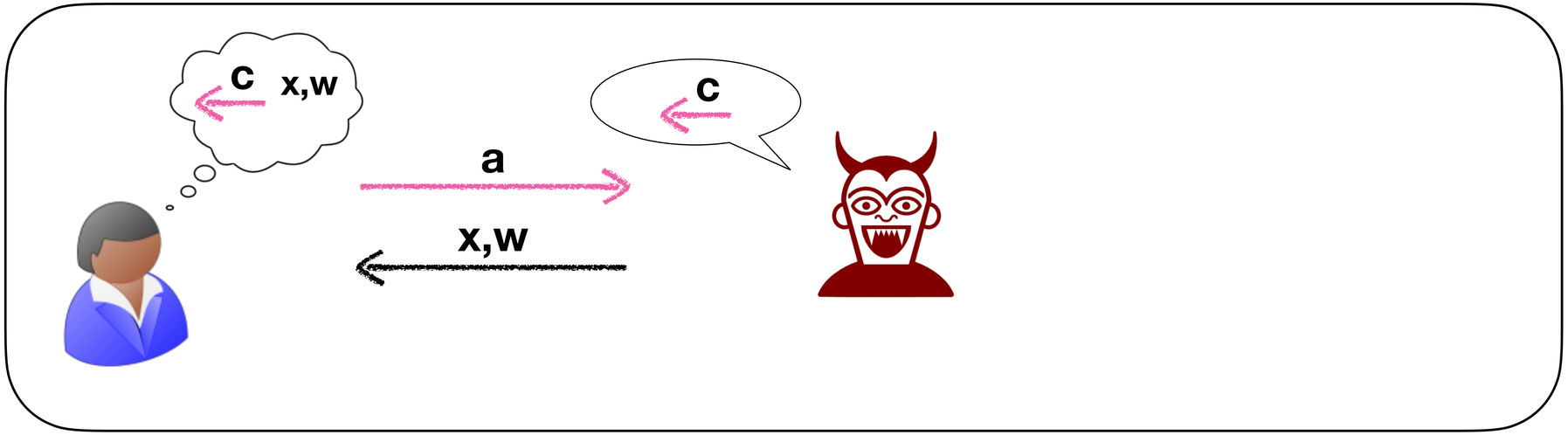

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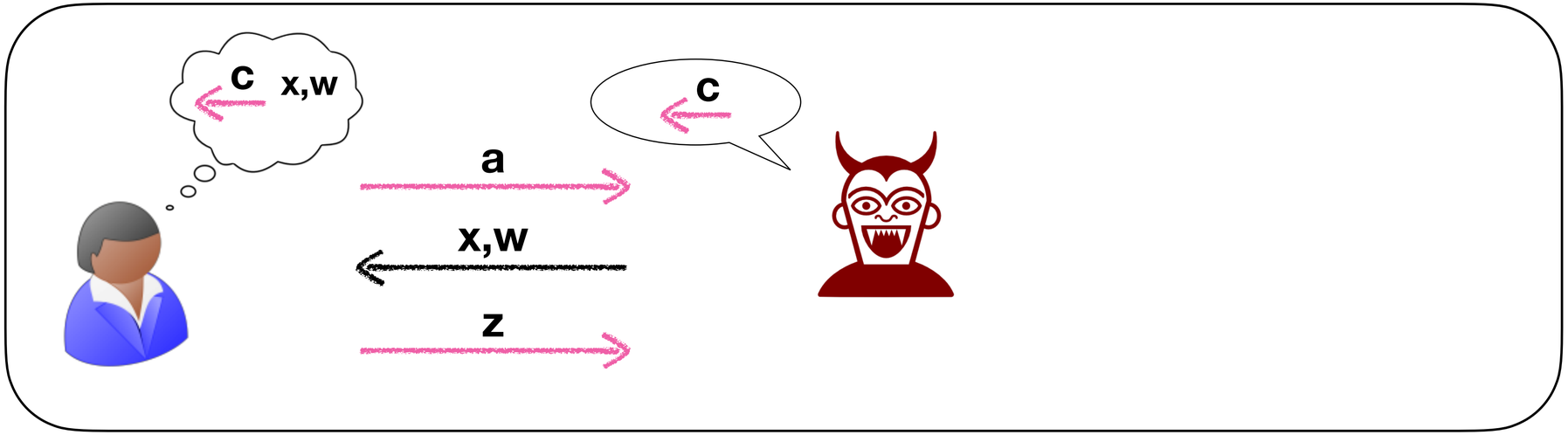

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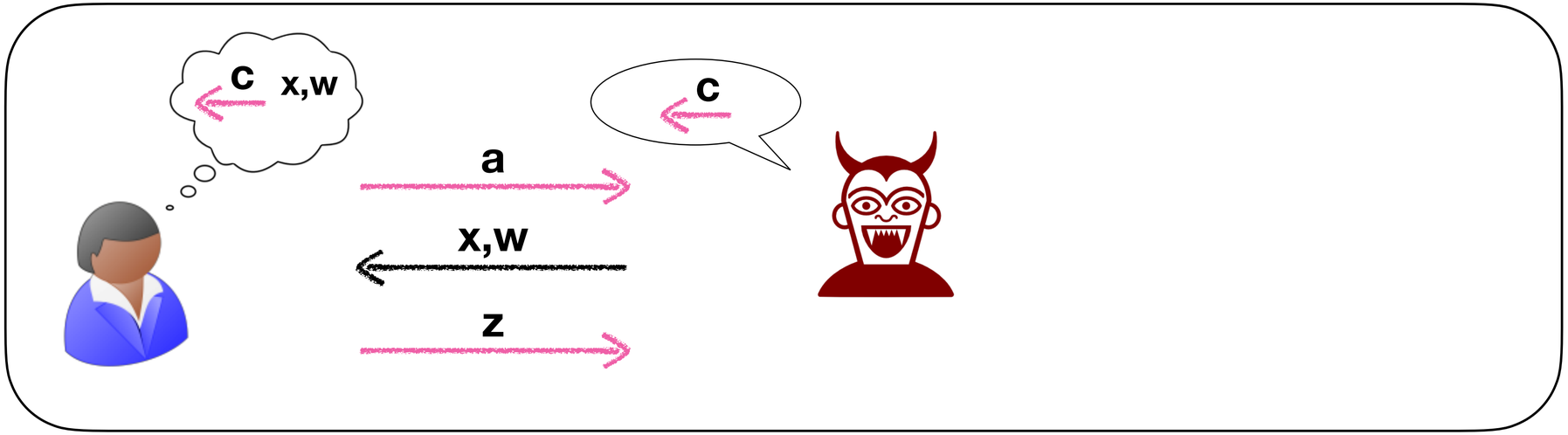

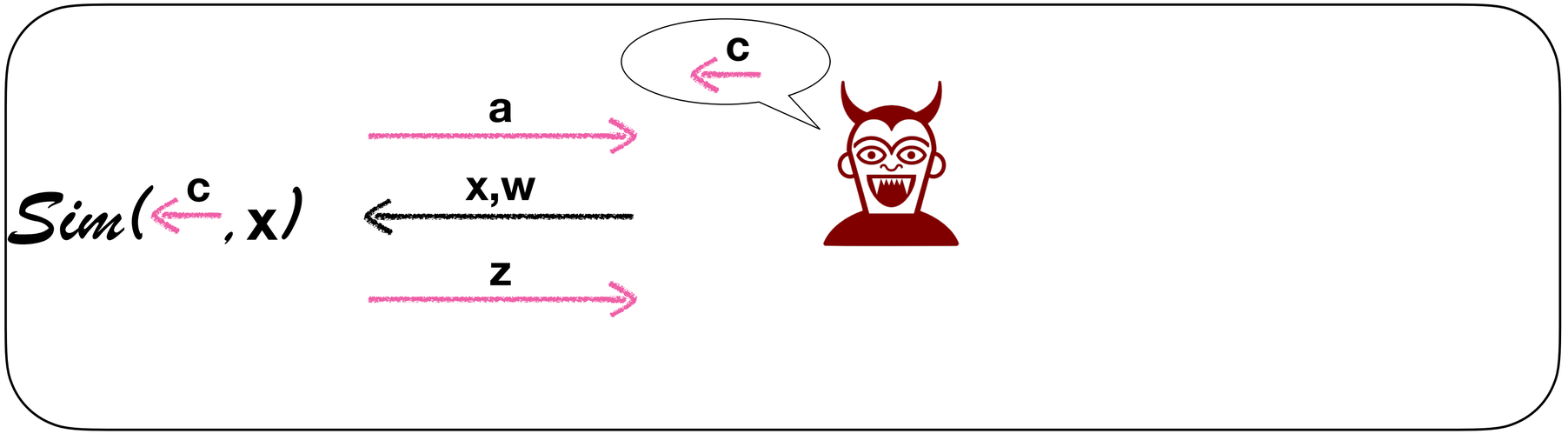

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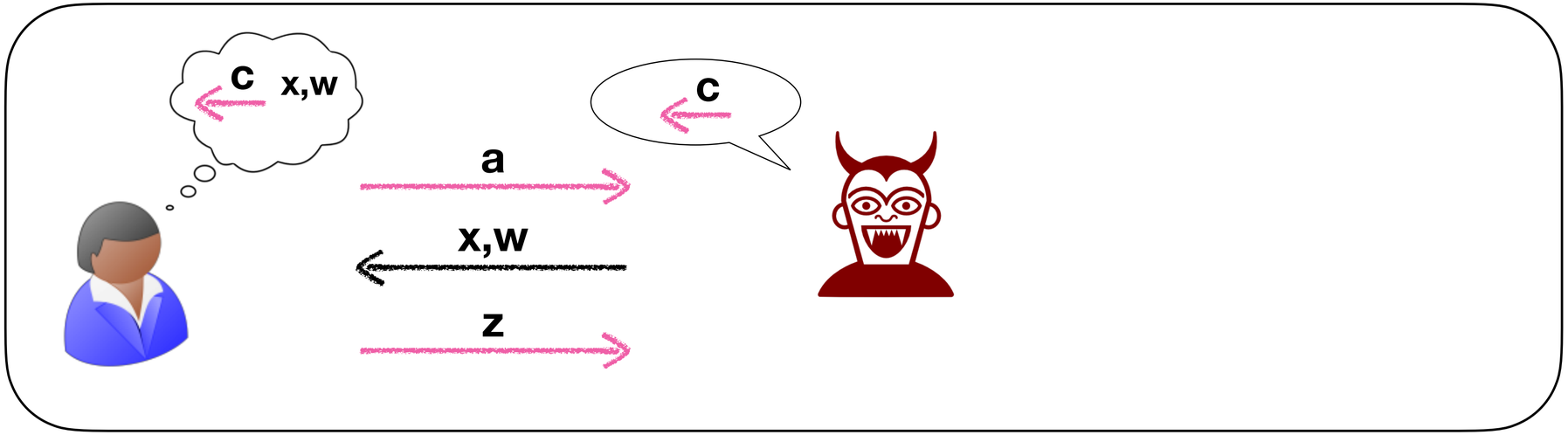
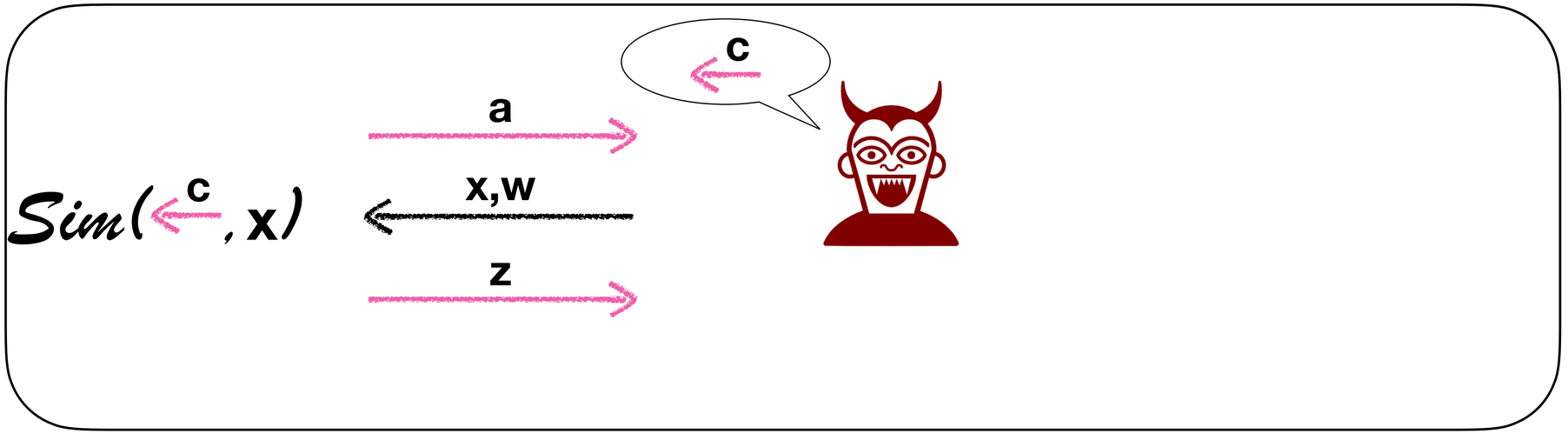


$\approx$

$D_{HVZK}(view)$



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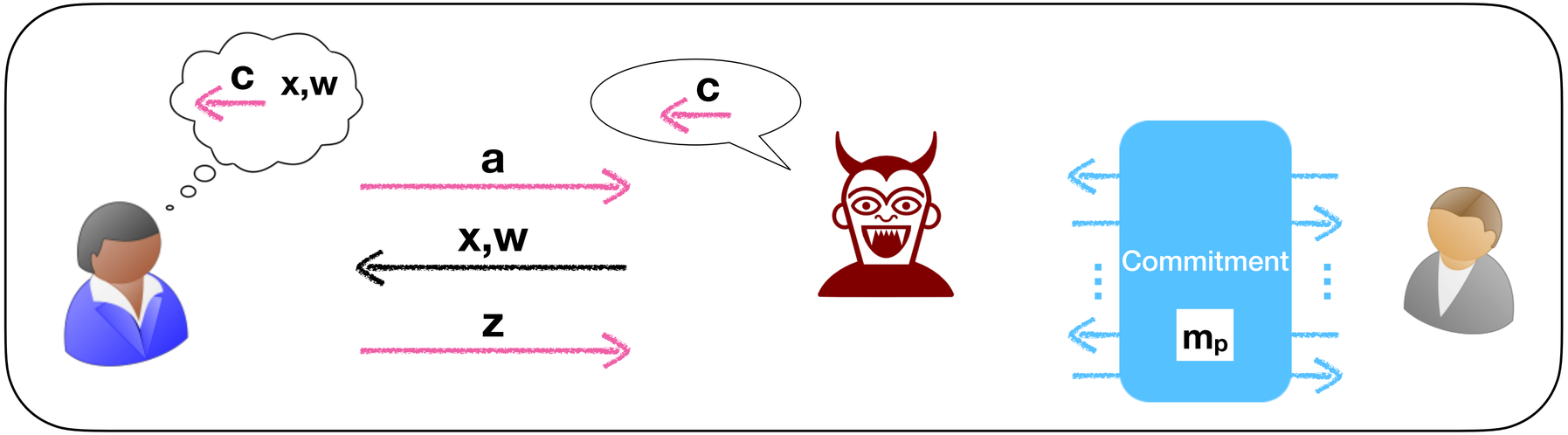

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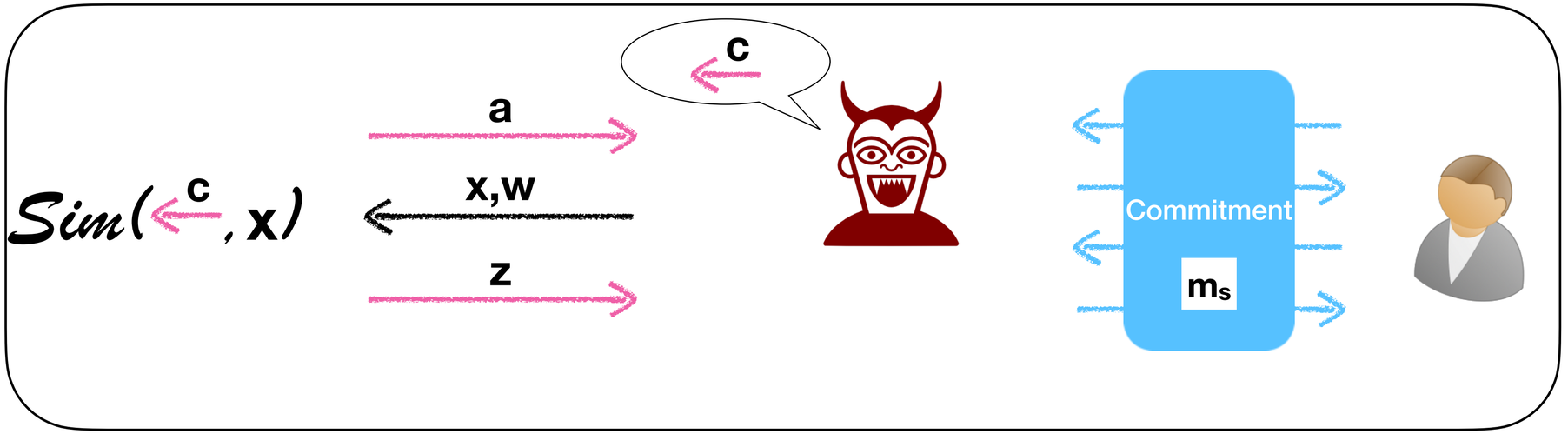

$Sim(\overleftarrow{c}, x)$

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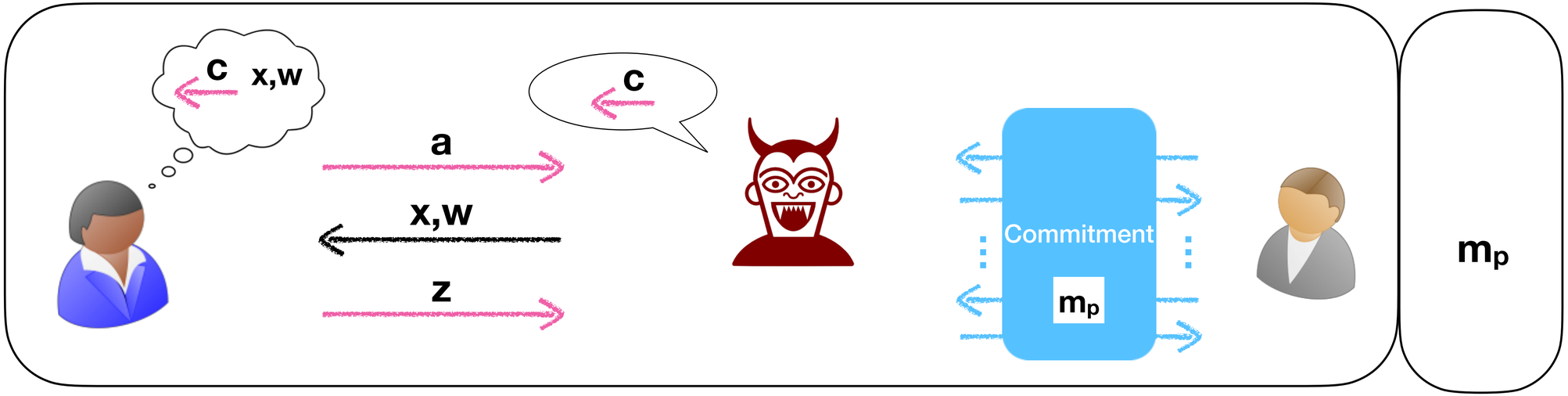
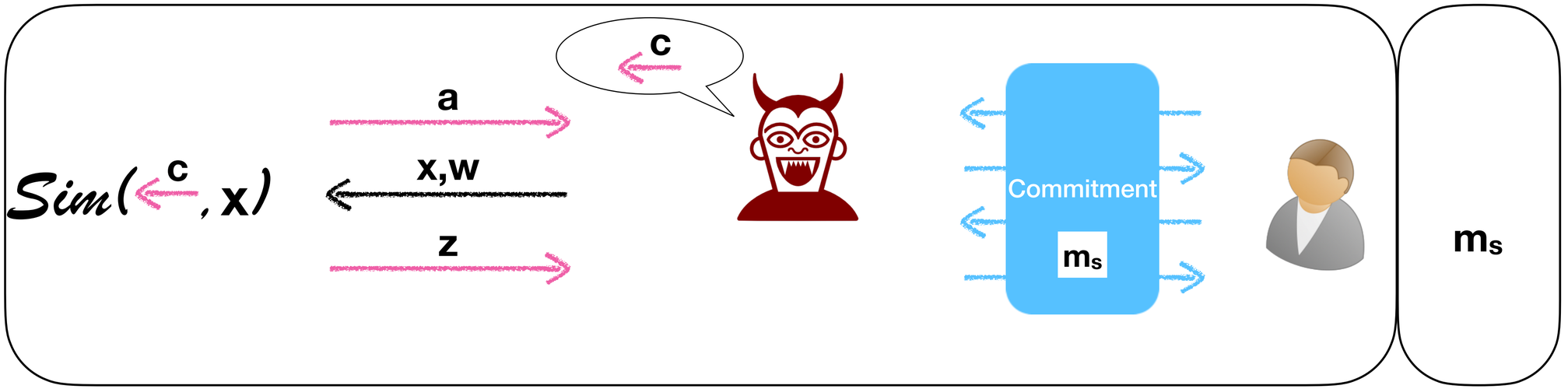
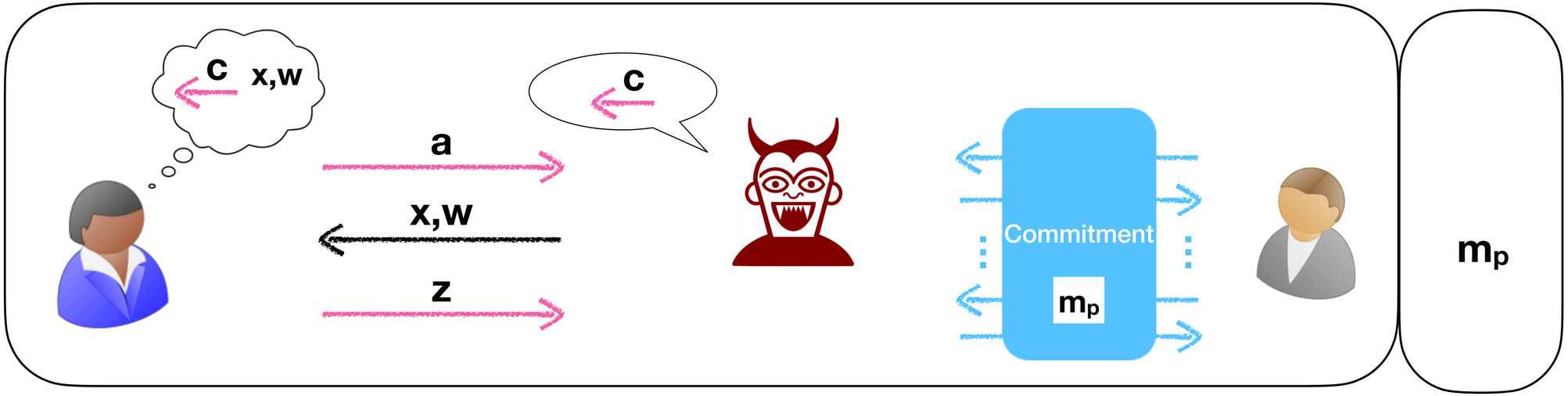


$\approx$

$\mathcal{D}_{\text{HVZK}}(\text{view})$



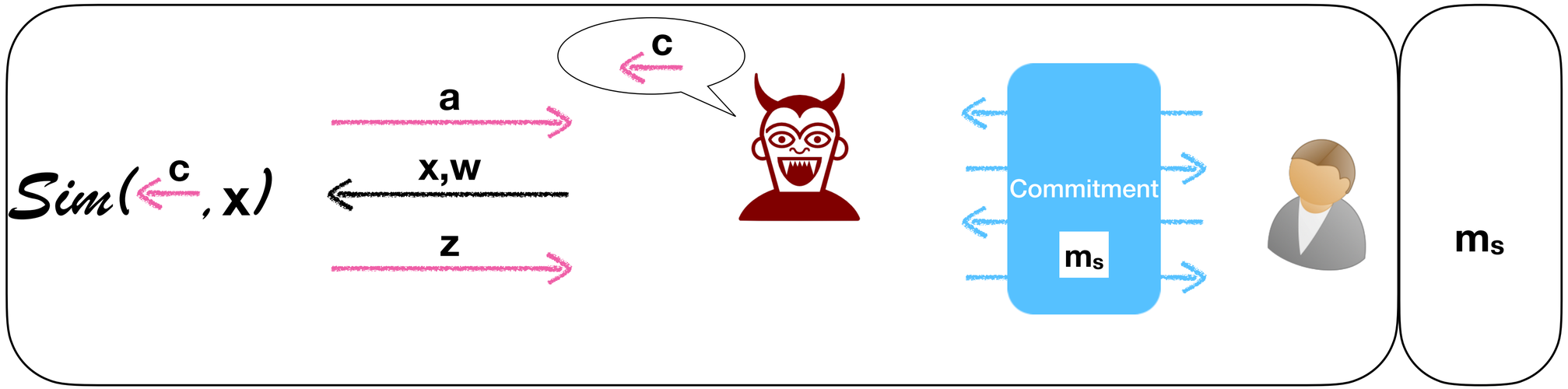
Honest verifier zero-knowledge with respect to commitments (HVZK**C**)



≈

$\mathcal{D}_{HVZK}(view)$

$\mathcal{D}_{HVZKC}(view,m)$



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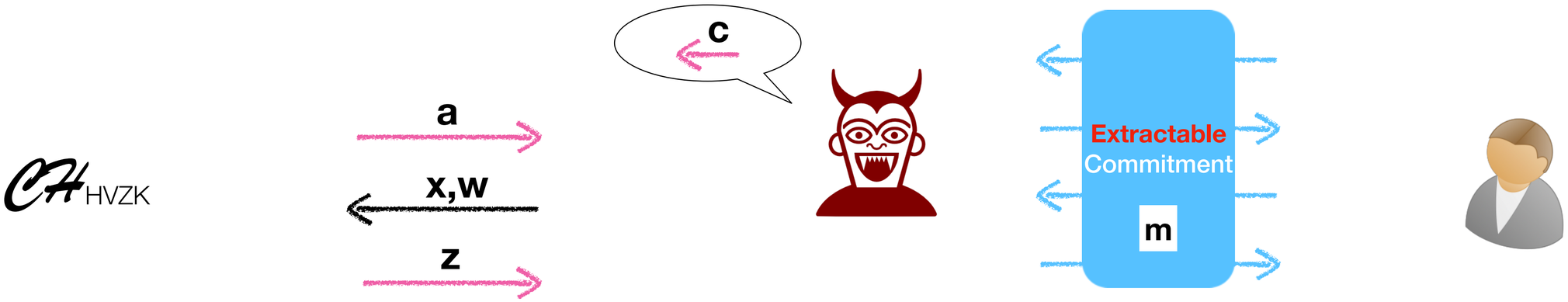

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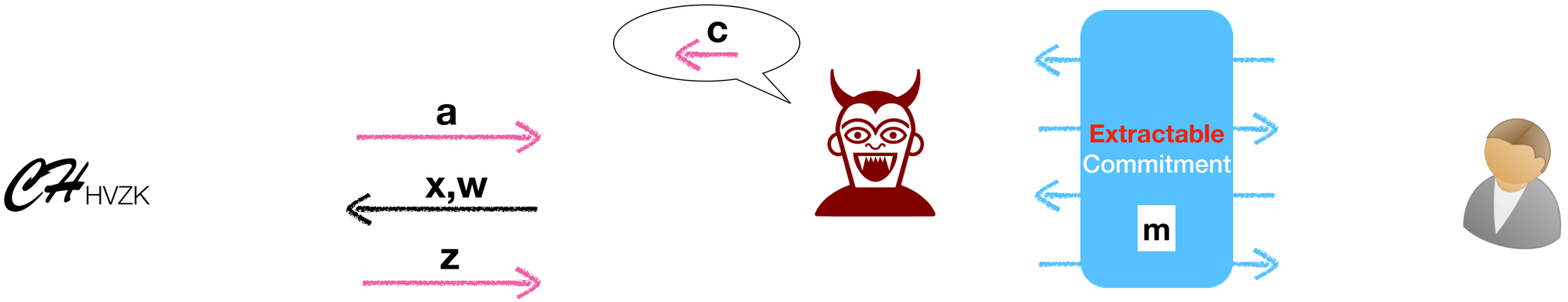

$\mathcal{D}_{\text{HVZK}\mathbf{C}}(\text{view},?)$

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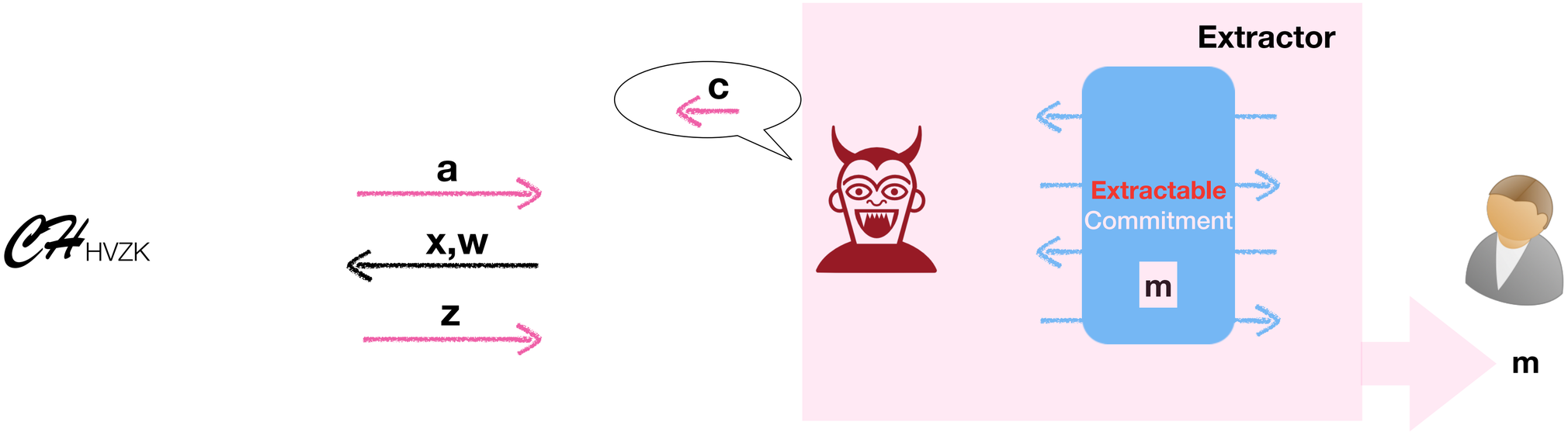

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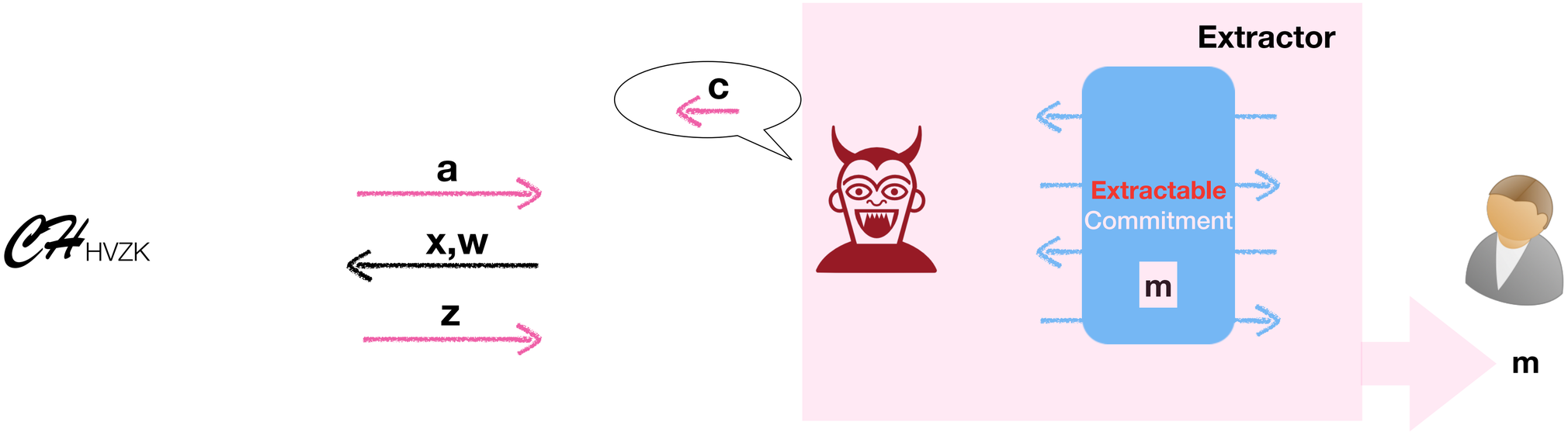

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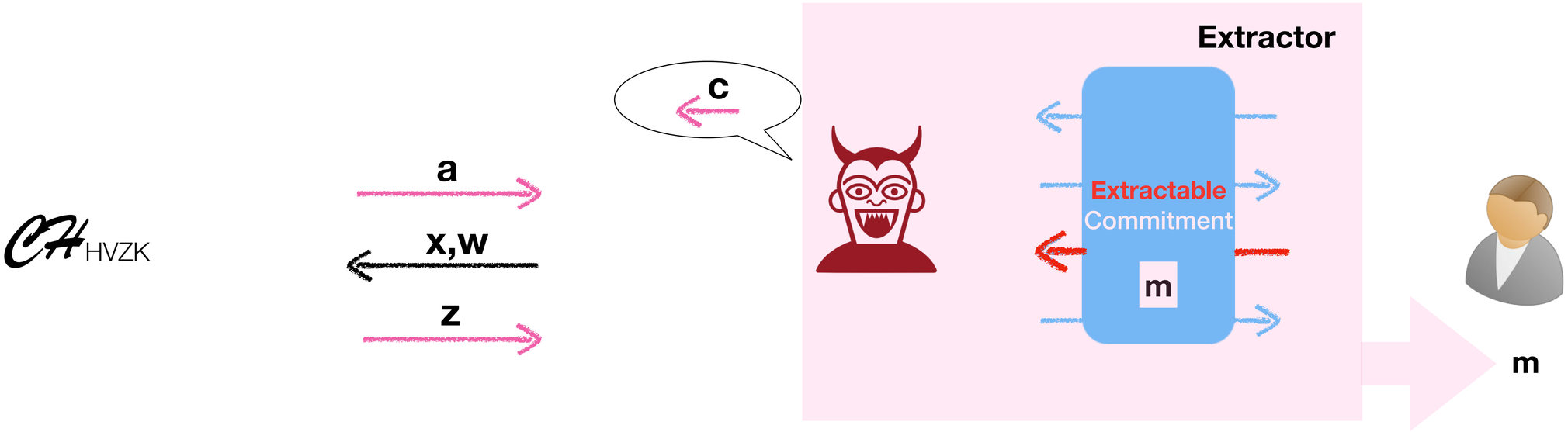

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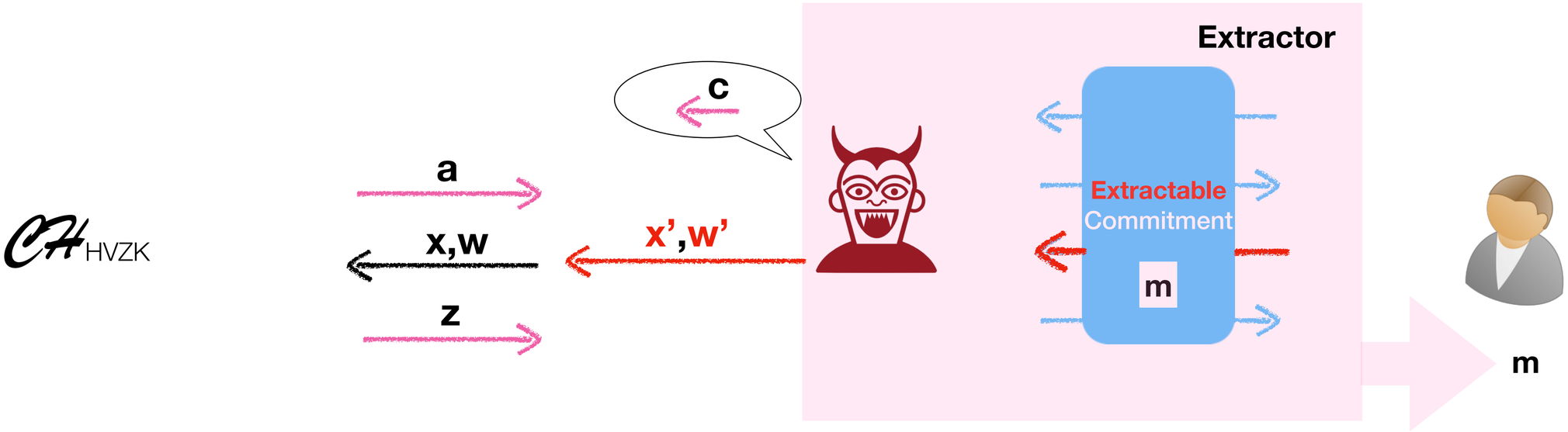

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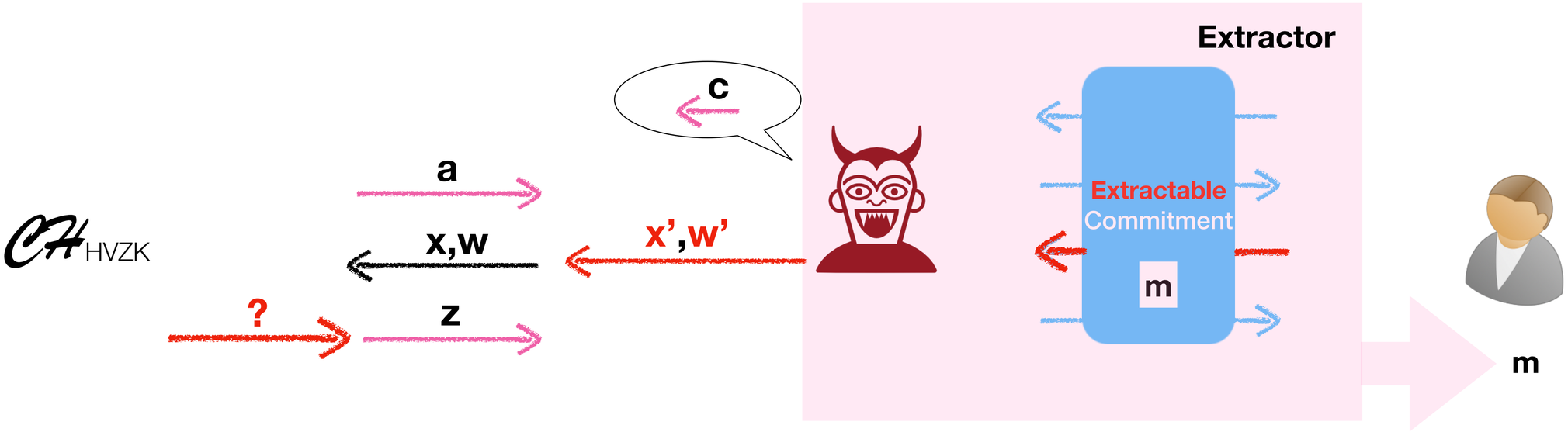

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Our HVZK**C** Scheme

[BMR90]

MPC

Preprocessing

Online phase

[BMR90] Donald Beaver, Silvio Micali, and Phillip Rogaway. STOC 1990

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+

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ZK from MPC

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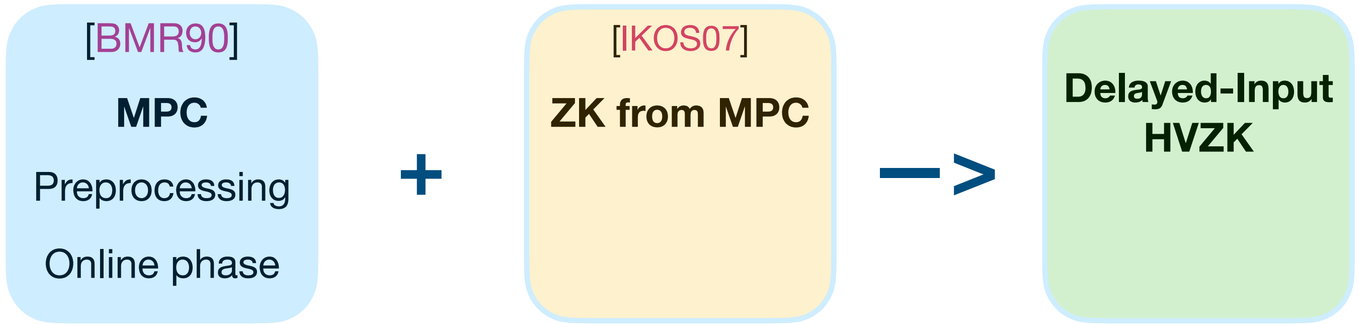

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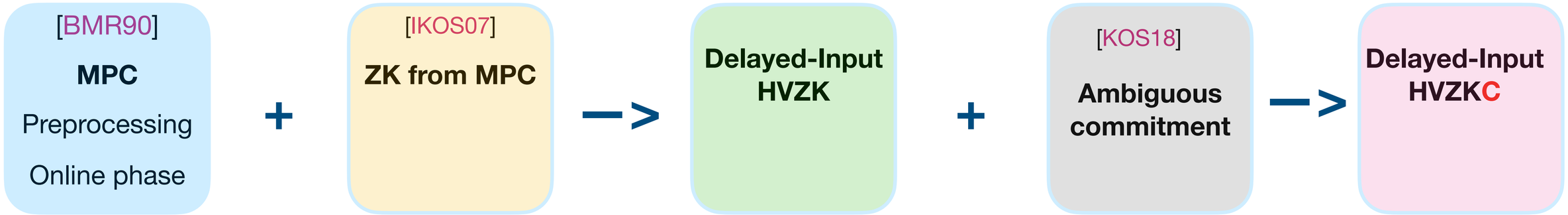

[BMR90] Donald Beaver, Silvio Micali, and Phillip Rogaway. STOC 1990

[IKOS07] Yuval Ishai, Eyal Kushilevitz, Rafail Ostrovsky, and Amit Sahai. STOC 2007

[KOS18] Dakshita Khurana, Rafail Ostrovsky, and Akshayaram Srinivasan. TCC 2018

Conclusions and Open Questions

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- Rewind security may be unnecessarily strong for some applications

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- Open problems
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  - 3-round non-malleable commitments with BB use of OWFs
  - Extension to the many-many setting

Thanks

https://ia.cr/2022/1543