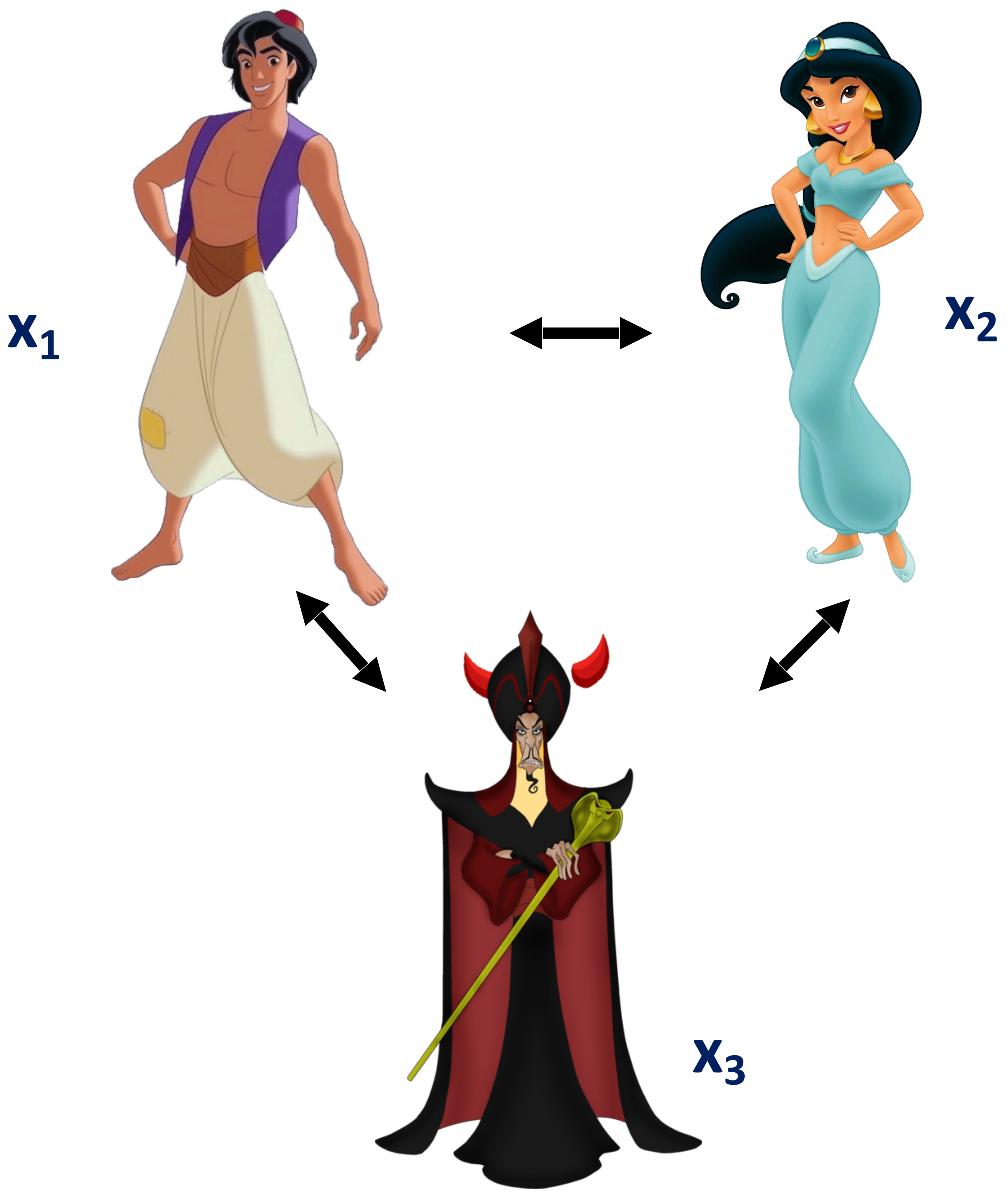
Fully-Secure MPC with Minimal Trust

Yuval Ishai, Arpita Patra, Sikhar Patranabis, **Divya Ravi**, Akshayaram Srinivasan

TCC 2022

Secure Multi-Party Computation



- Setup : n parties $\{P_1, P_2, \ldots., P_n\}$; t corrupt
- Input : P_i has input x_i
- Goal : Compute $\mathbf{f(x_1, x_2, x_3)}$

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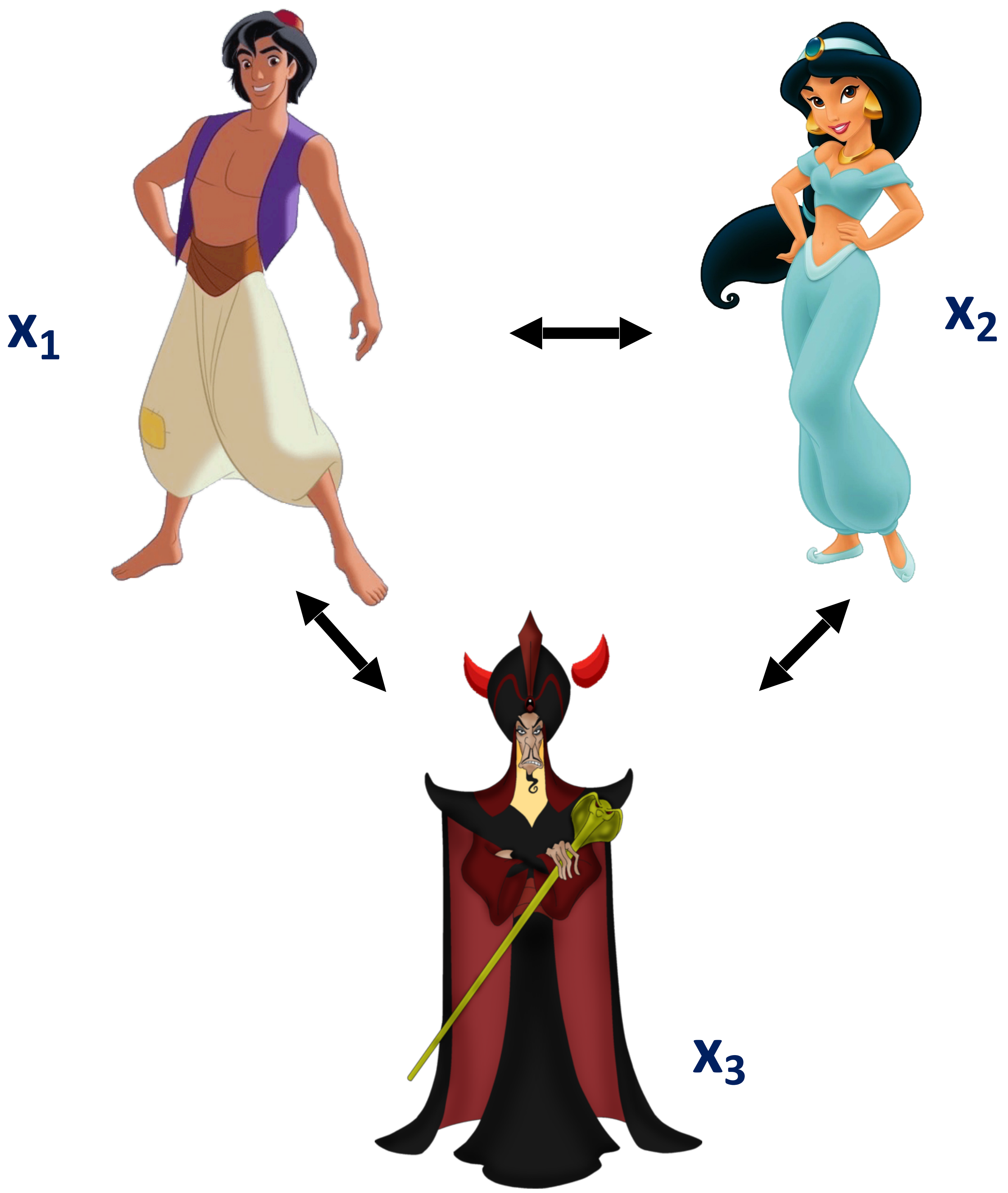

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- Properties:
  - Correctness : Protocol output = $f(x_1, x_2, x_3)$
  - Privacy : Nothing beyond function output revealed

Motivation

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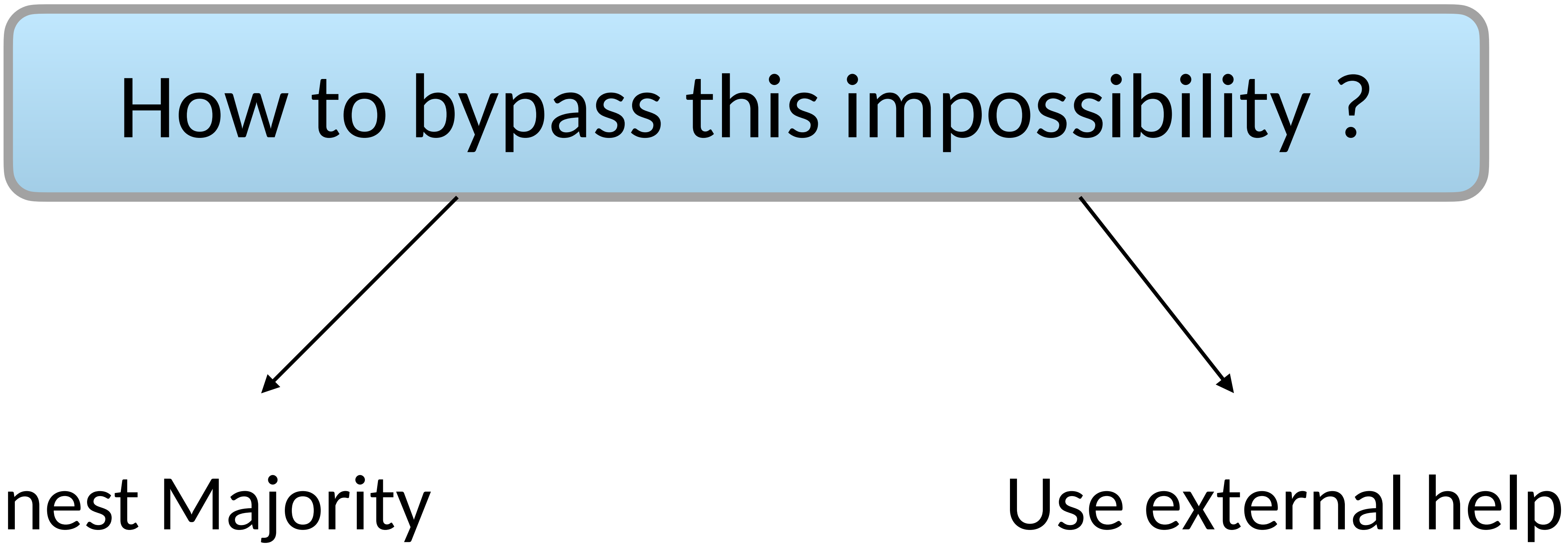

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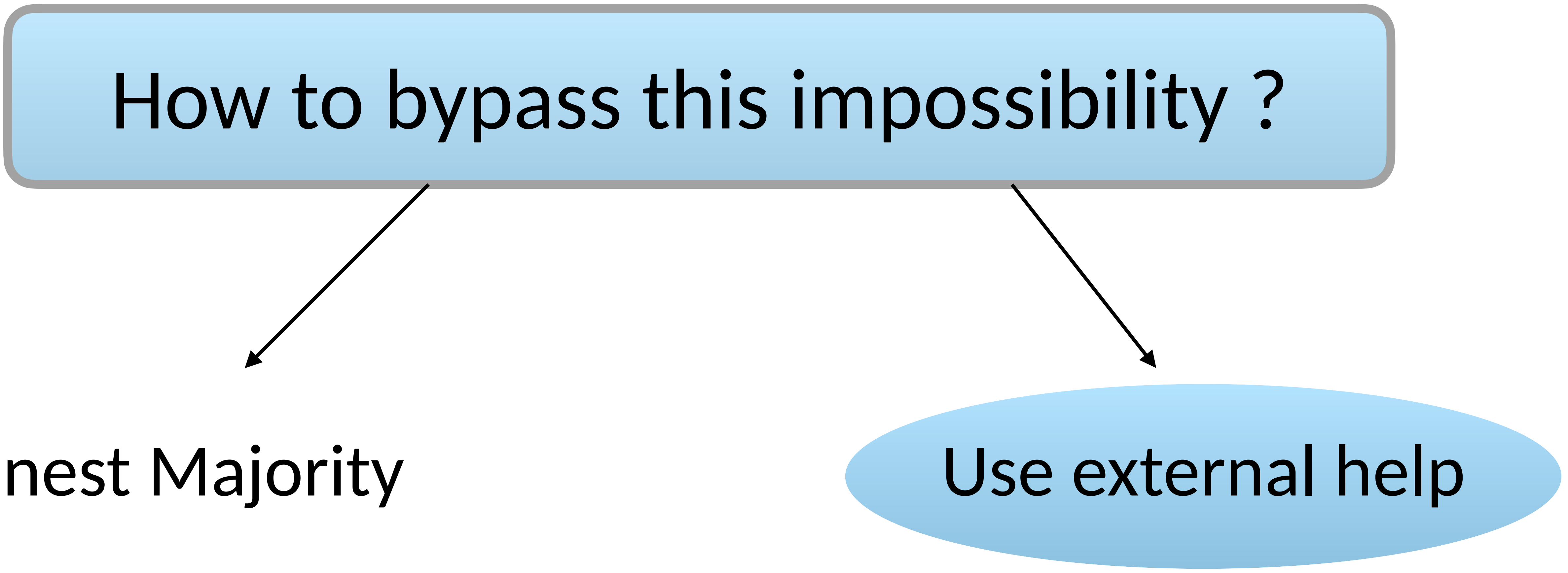

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GOAL	✓ **Small** poly(n, λ)	✓ **One**

Modelling the Trusted Party (TP)

TP realized by
Cloud service provider
charging fees ;
Large-scale Honest Majority
MPC

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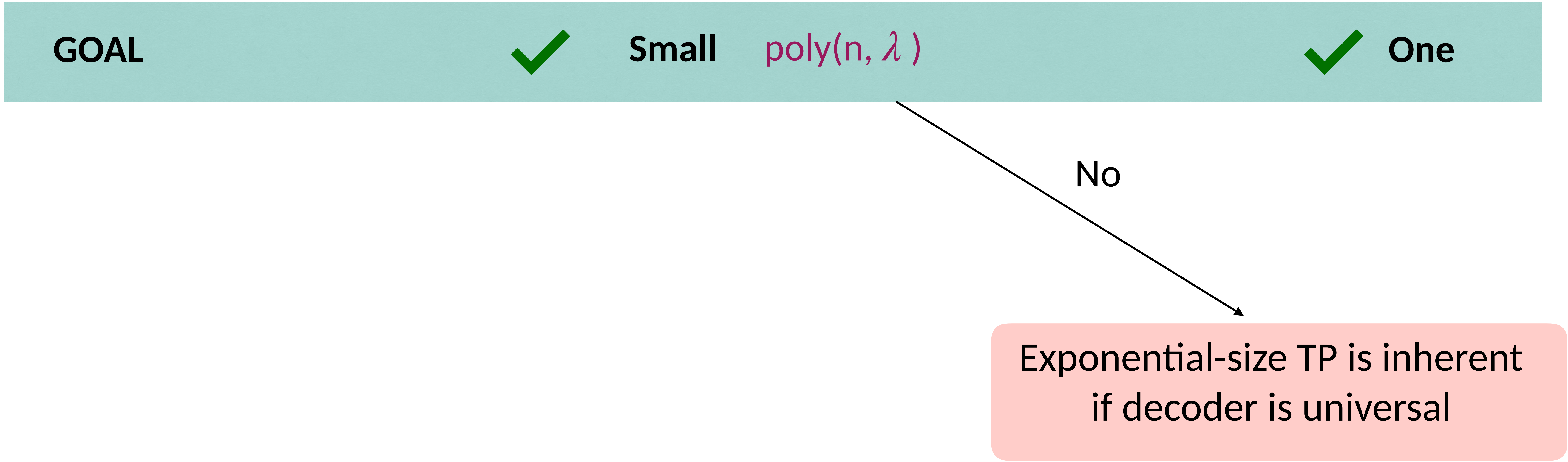

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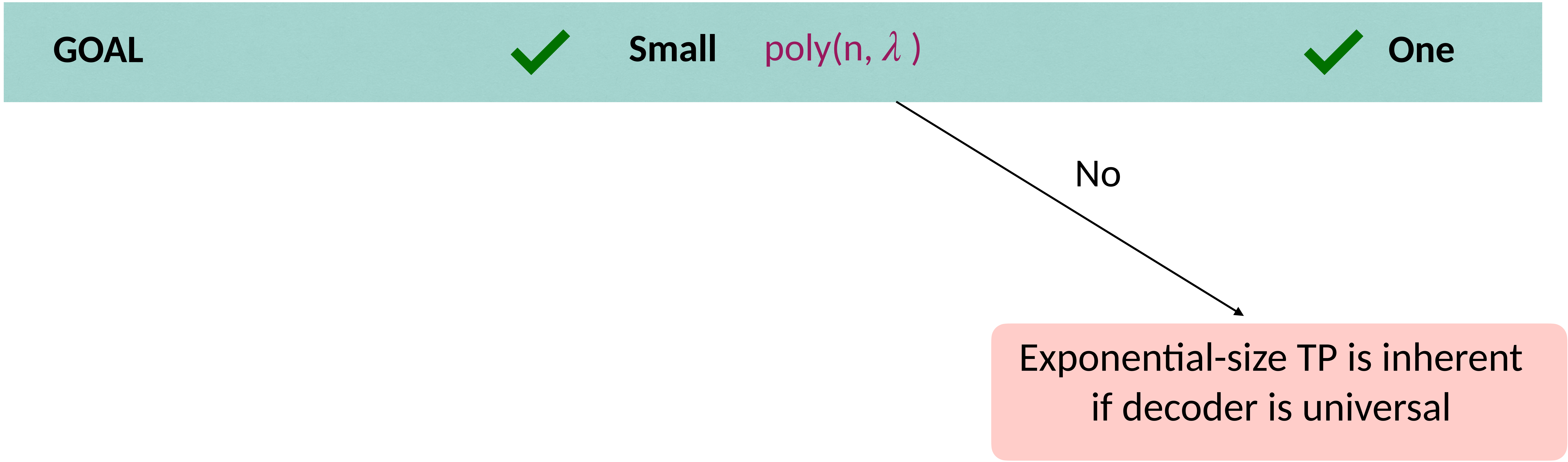

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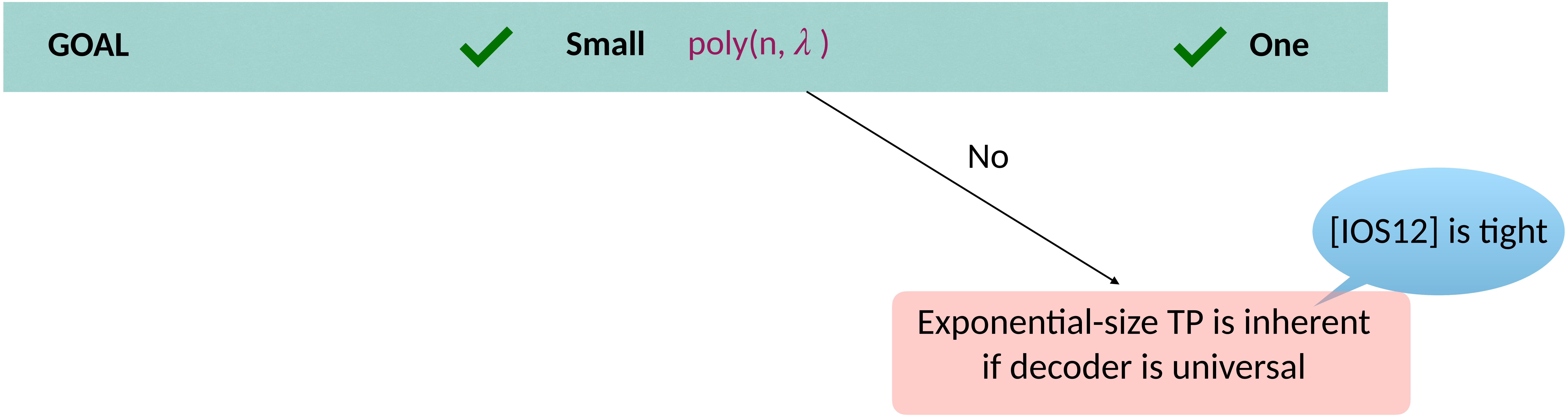

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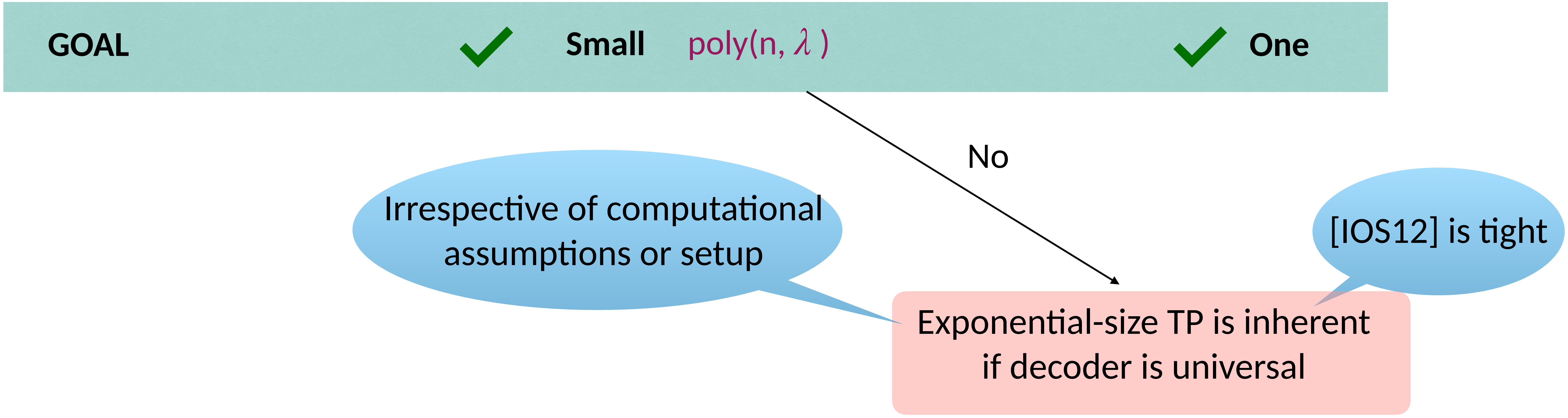

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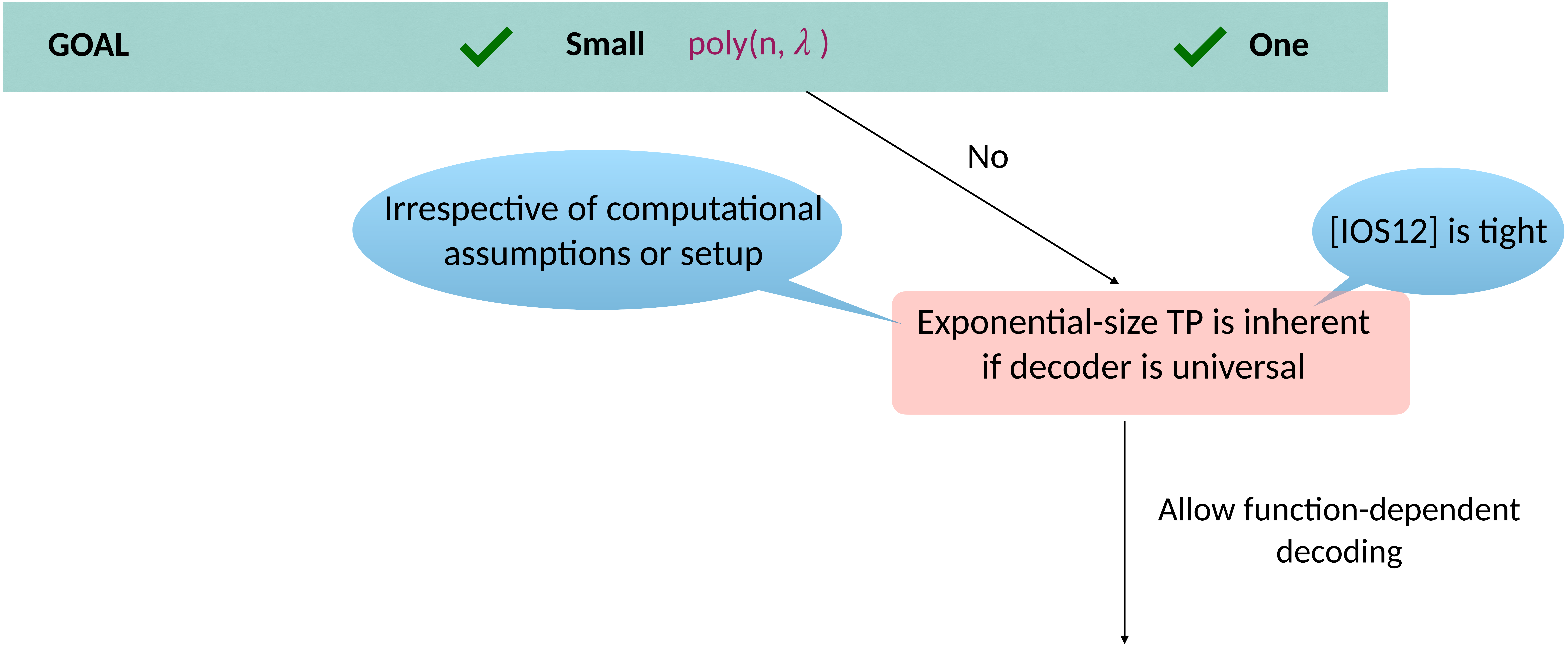

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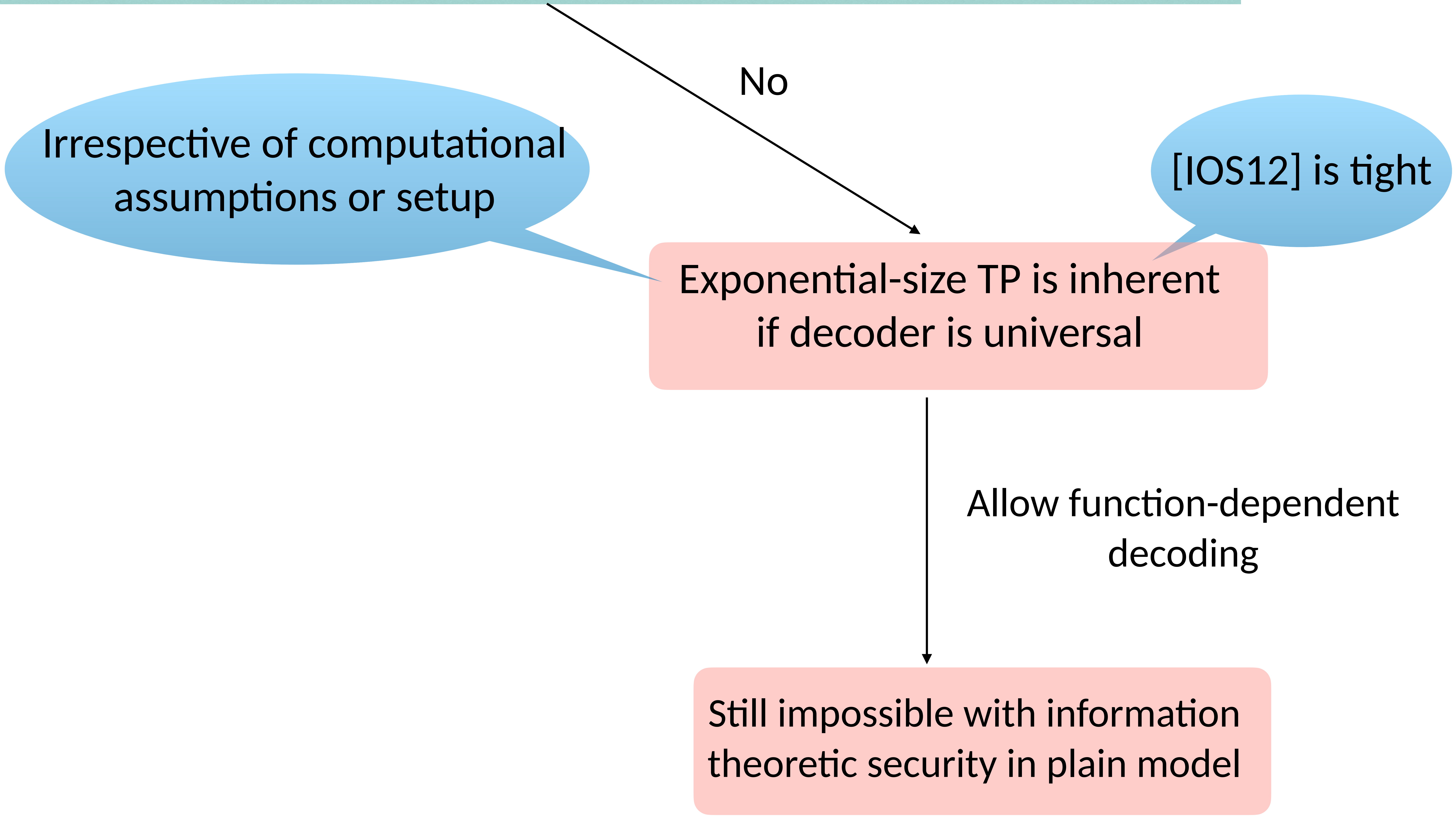

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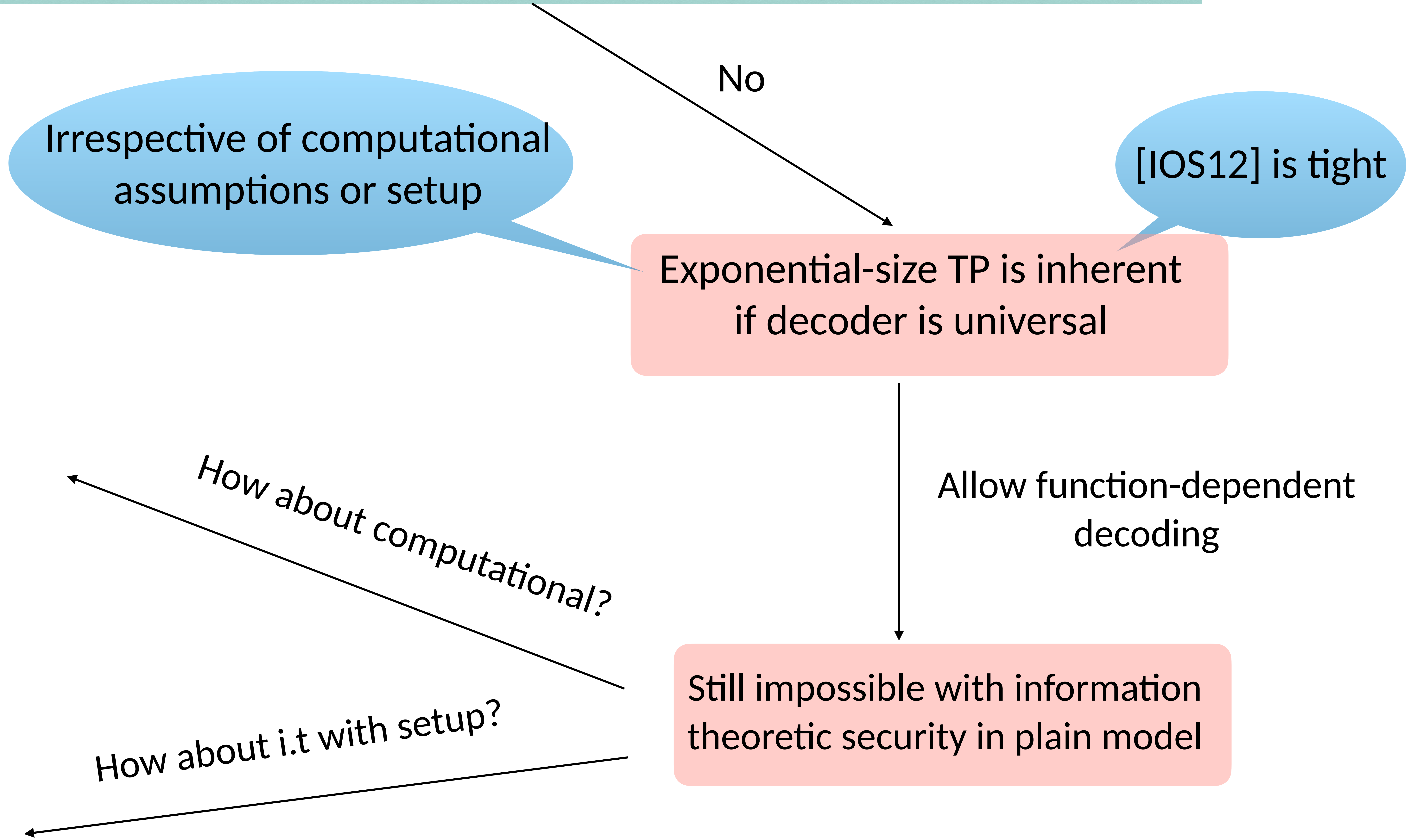

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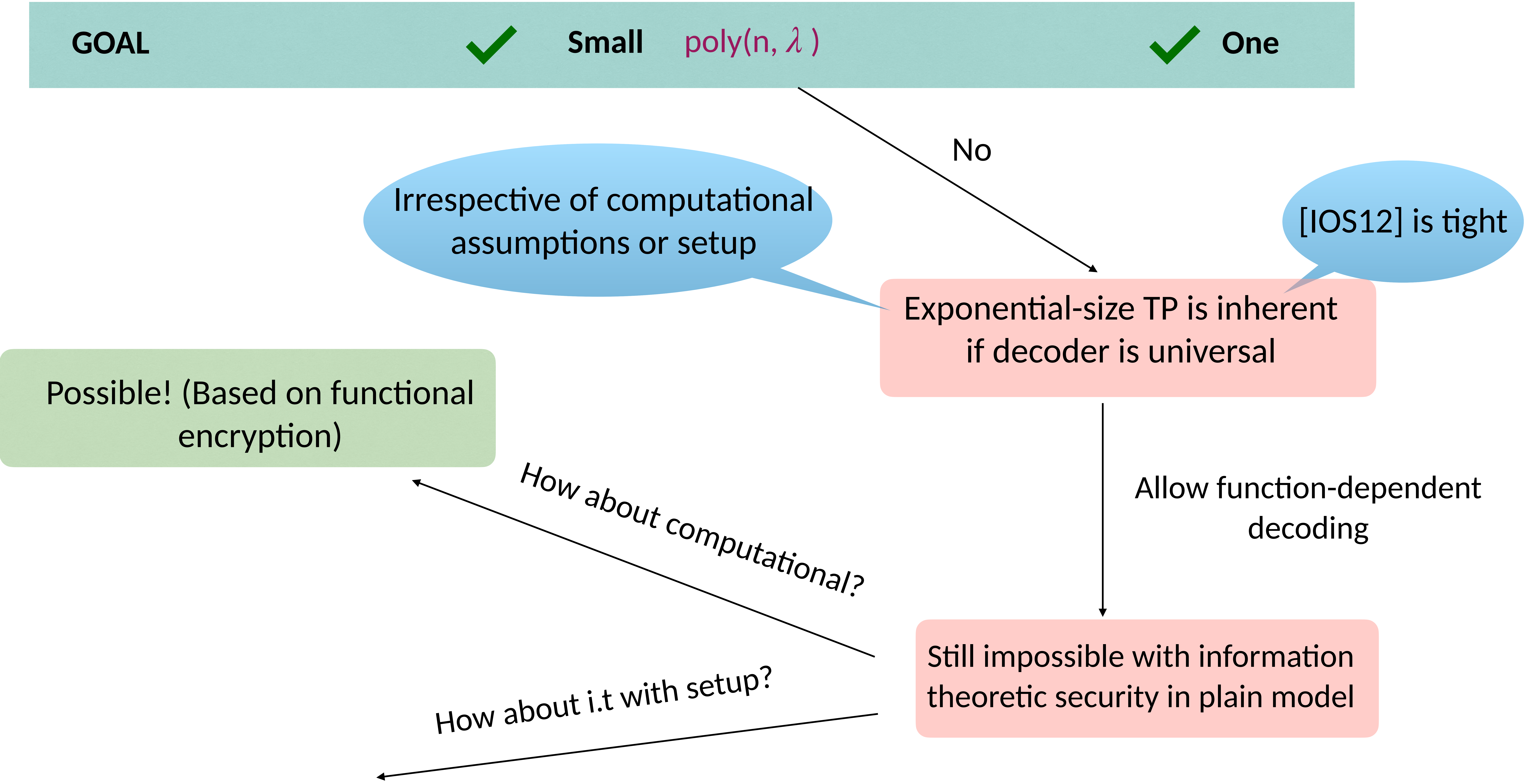

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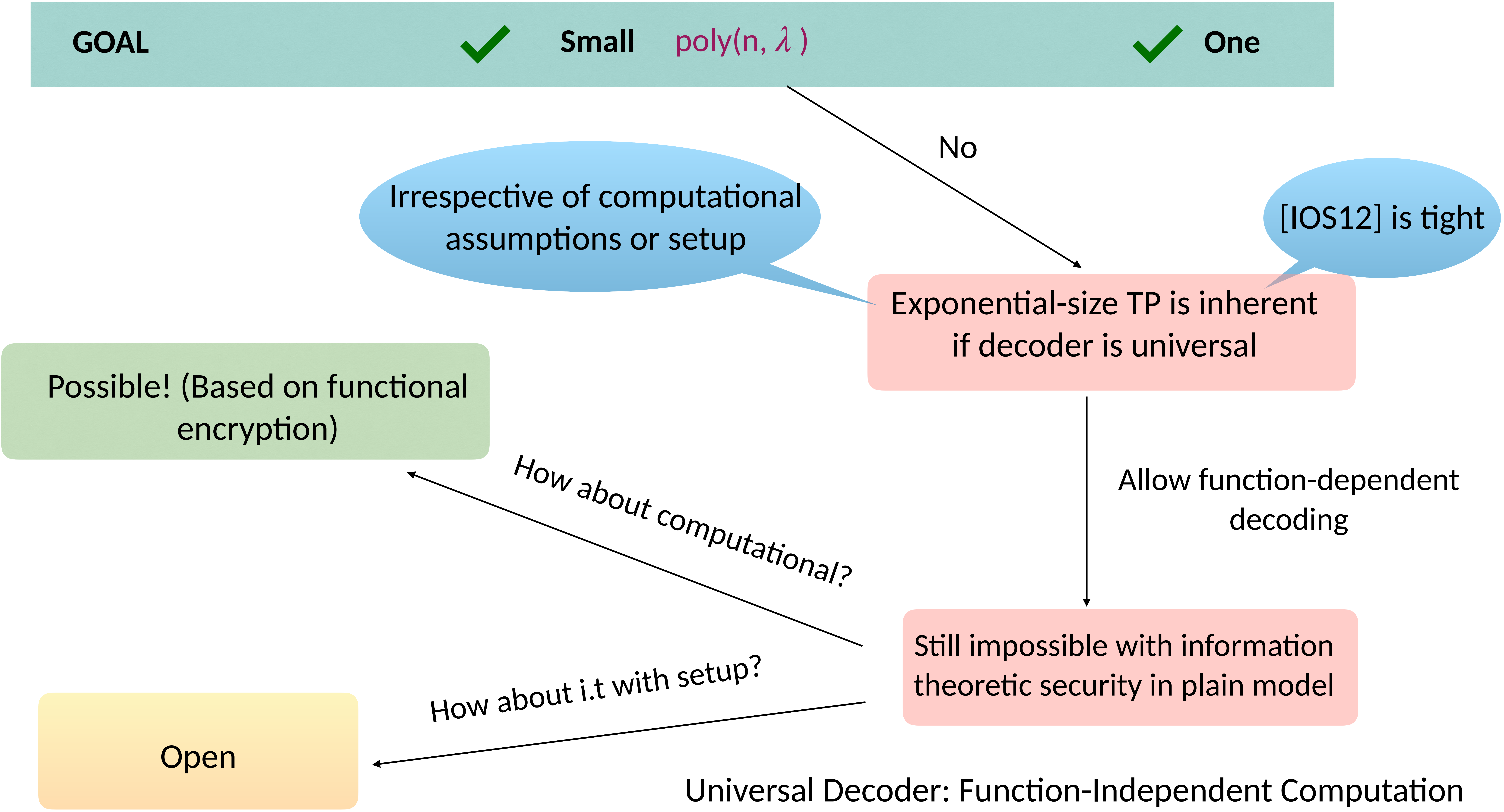

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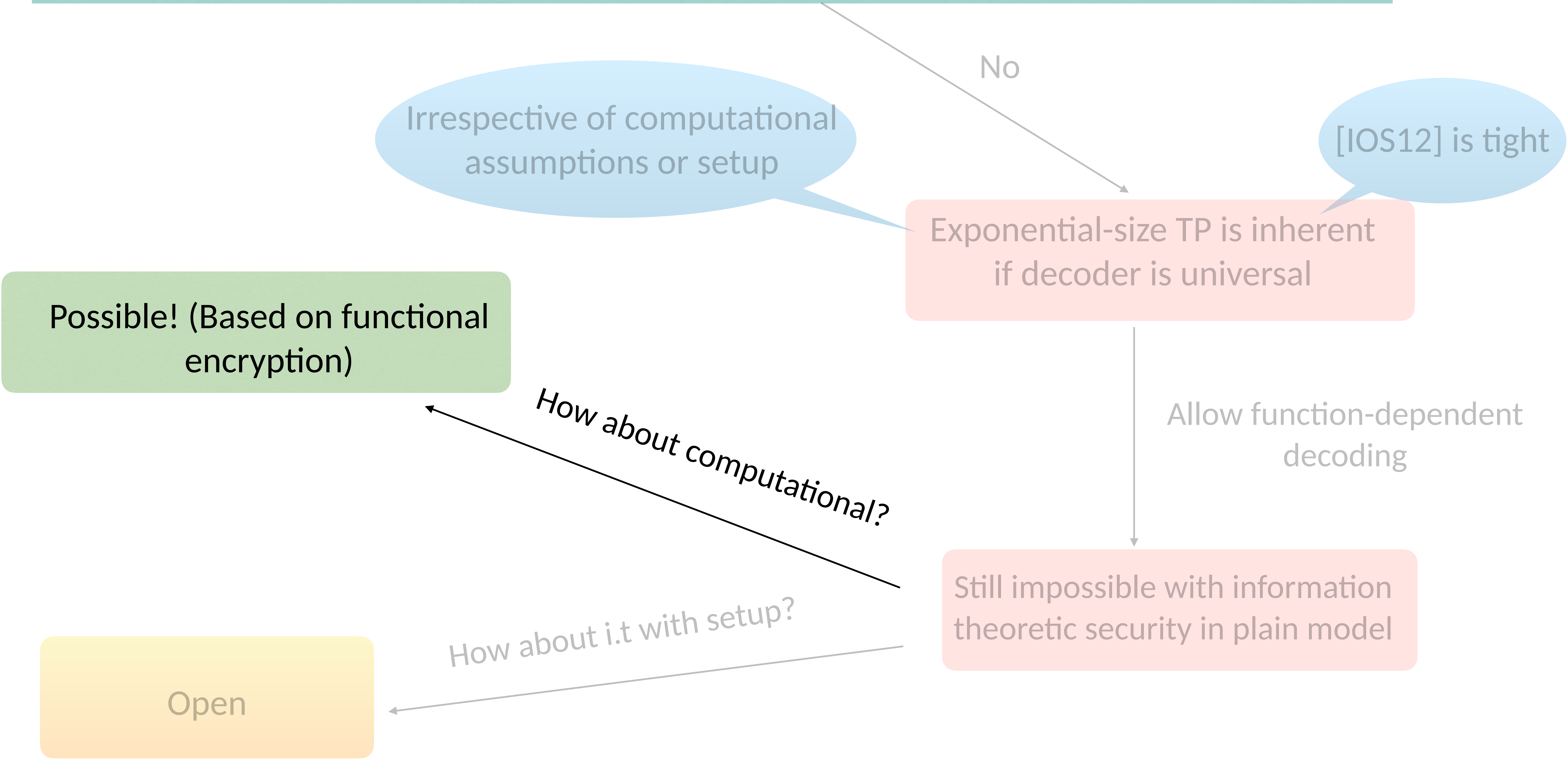

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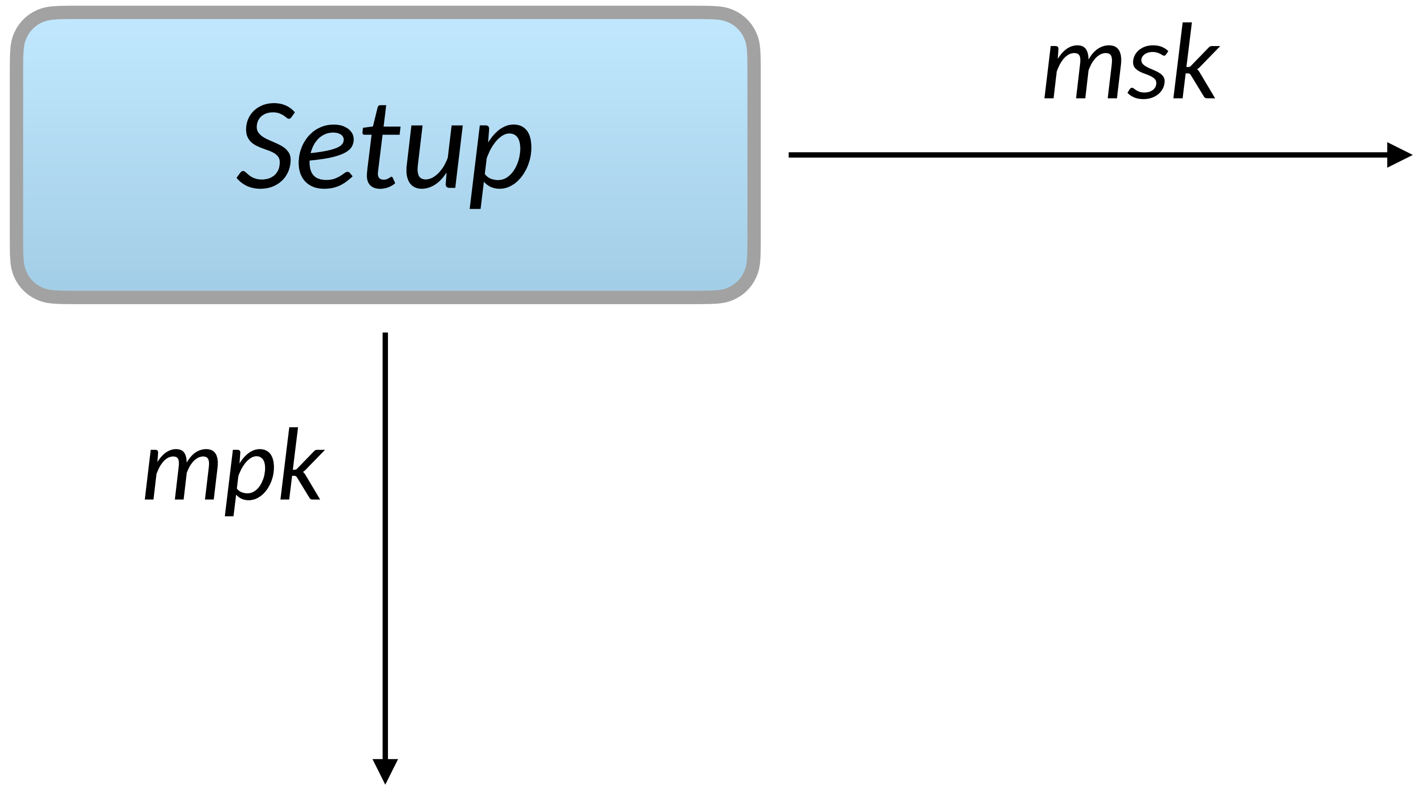

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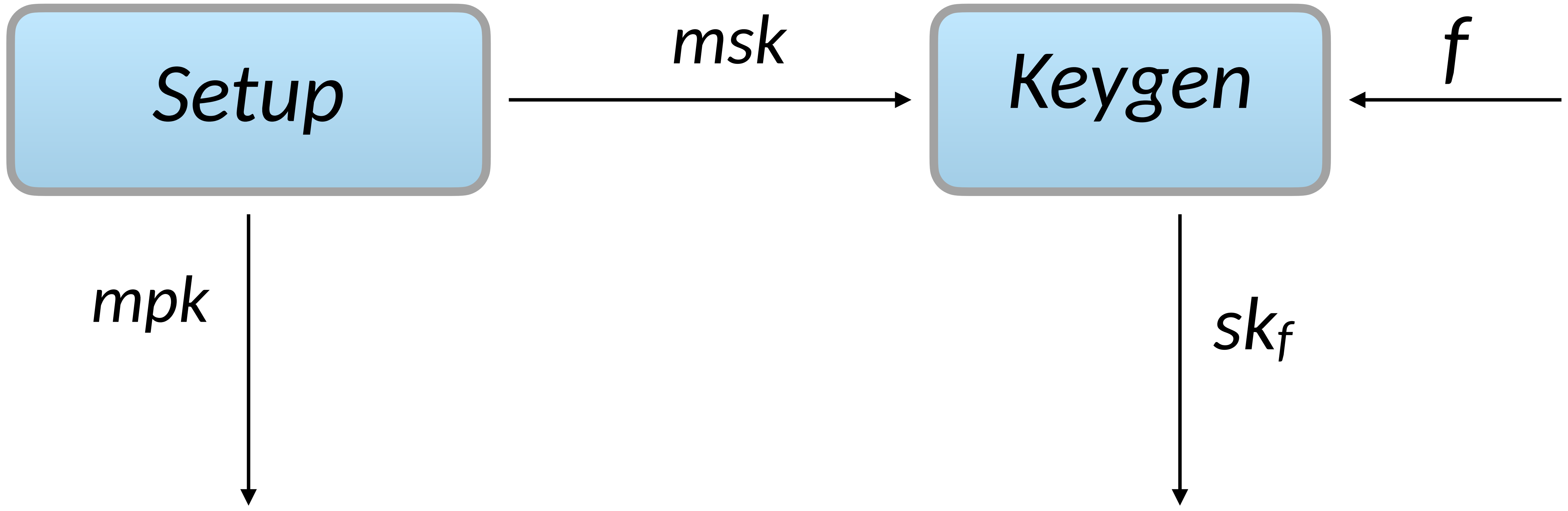

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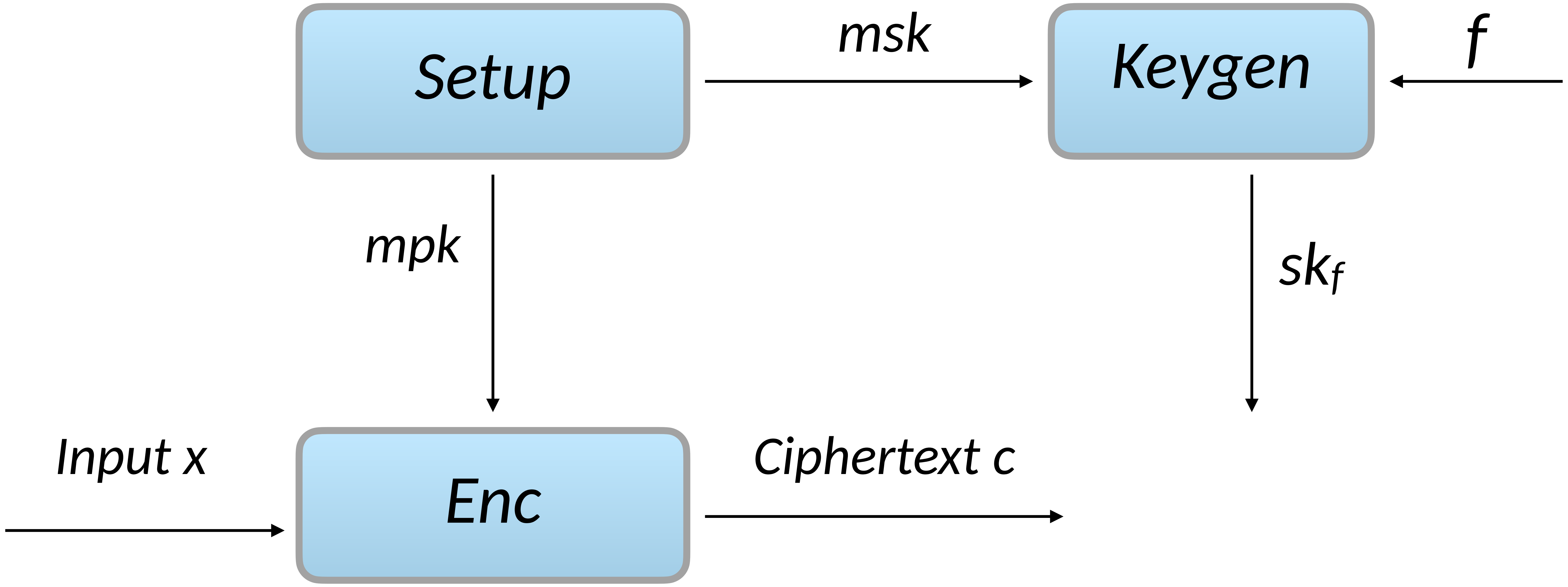

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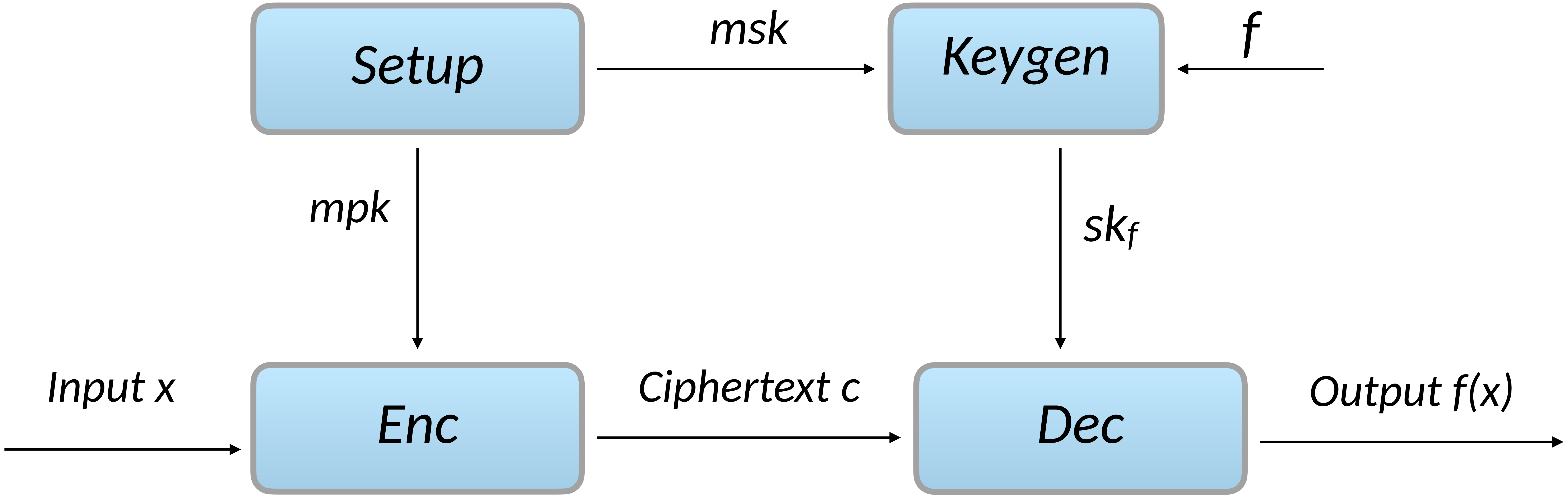

Fully-Secure MPC with 1 call to small TP

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MPC with identifiable abort

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Either output or at least one cheater identified

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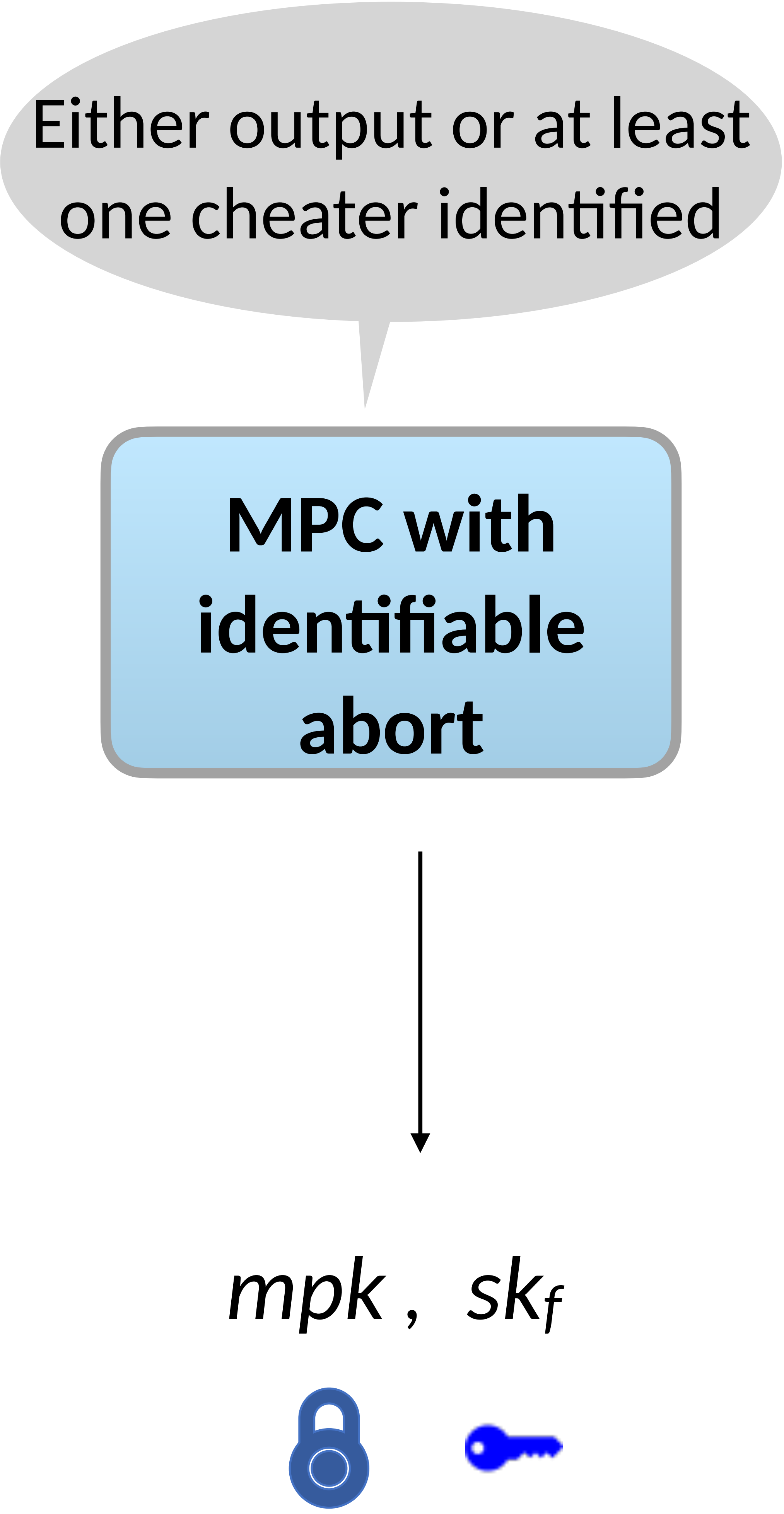

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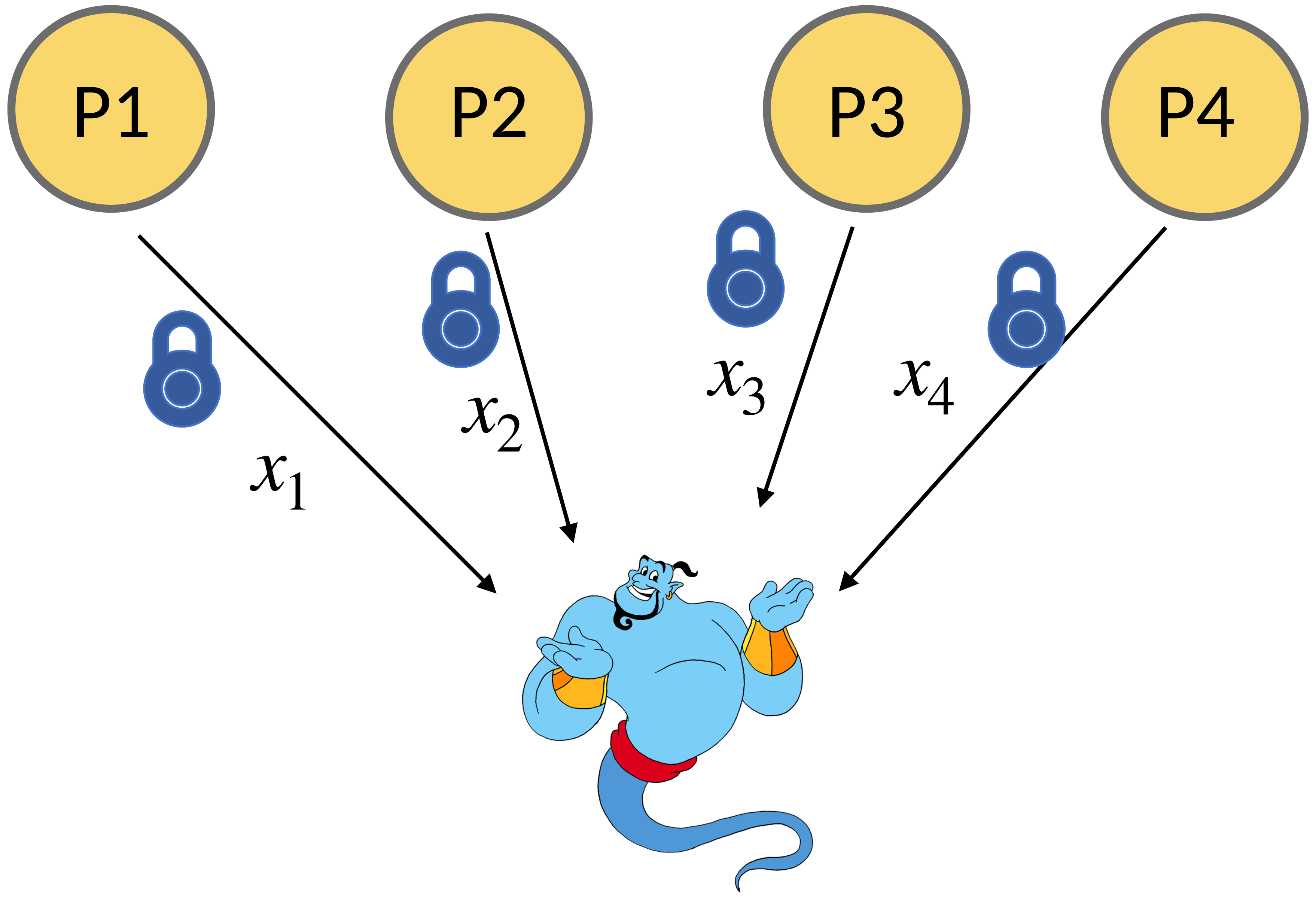

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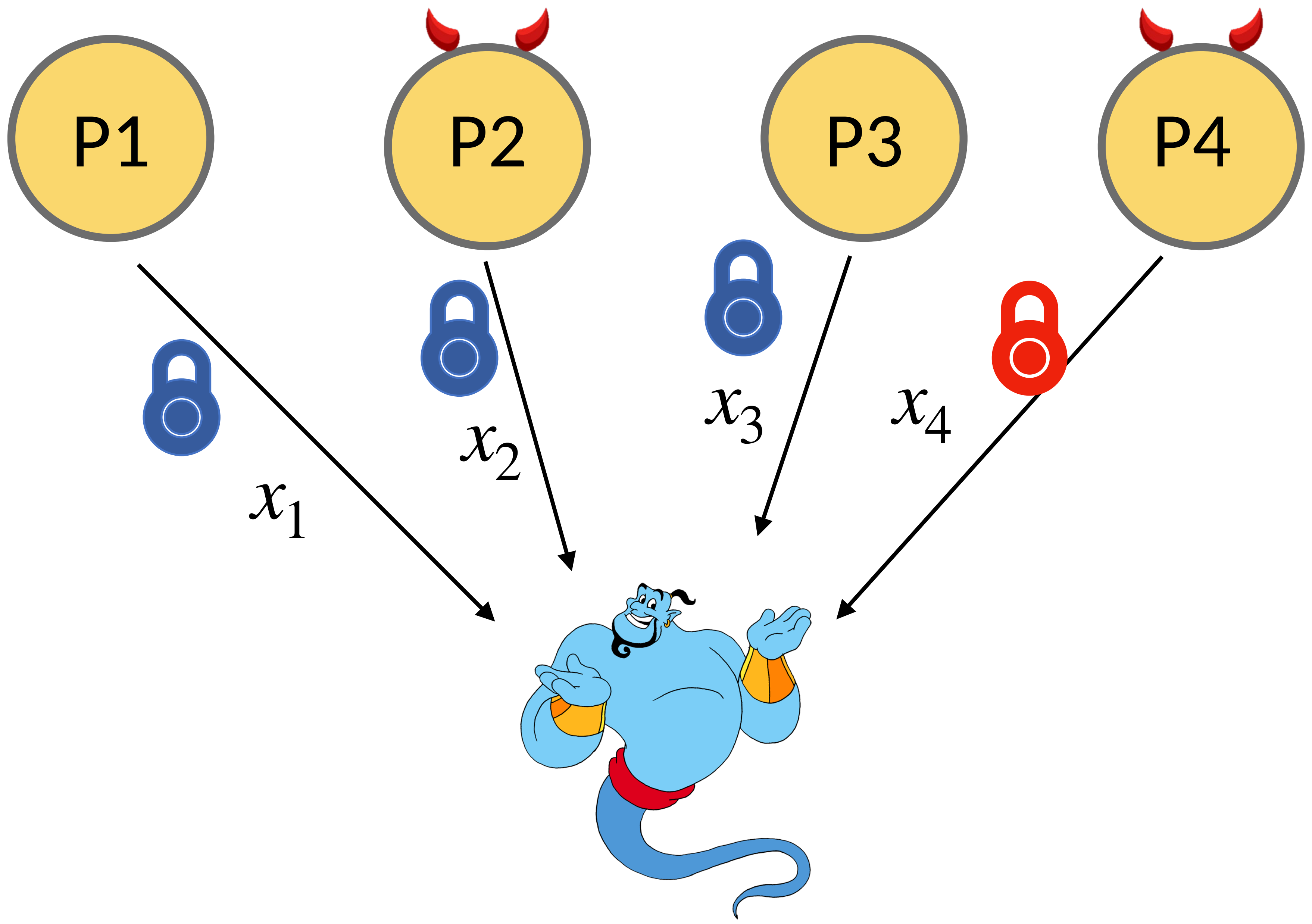

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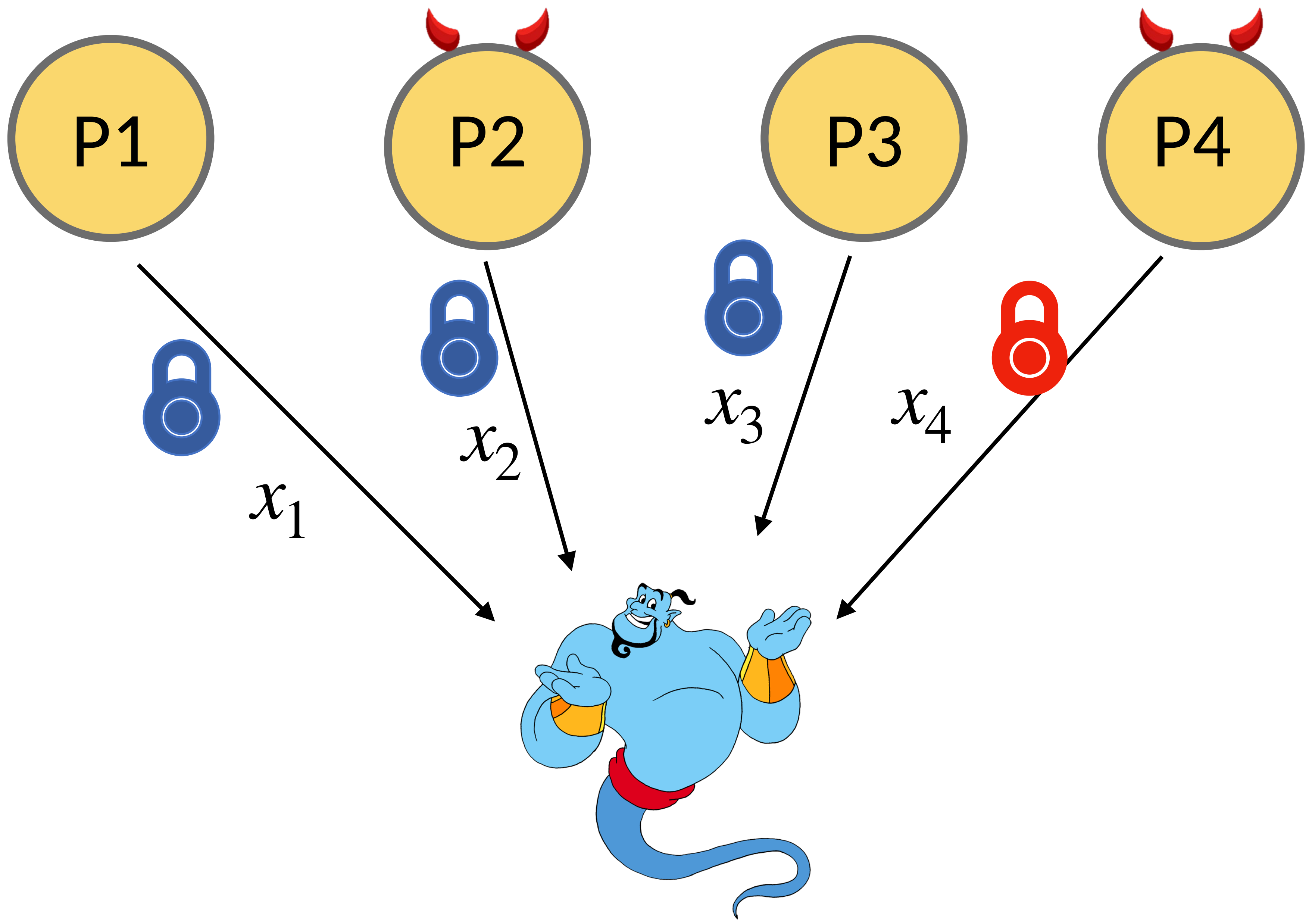

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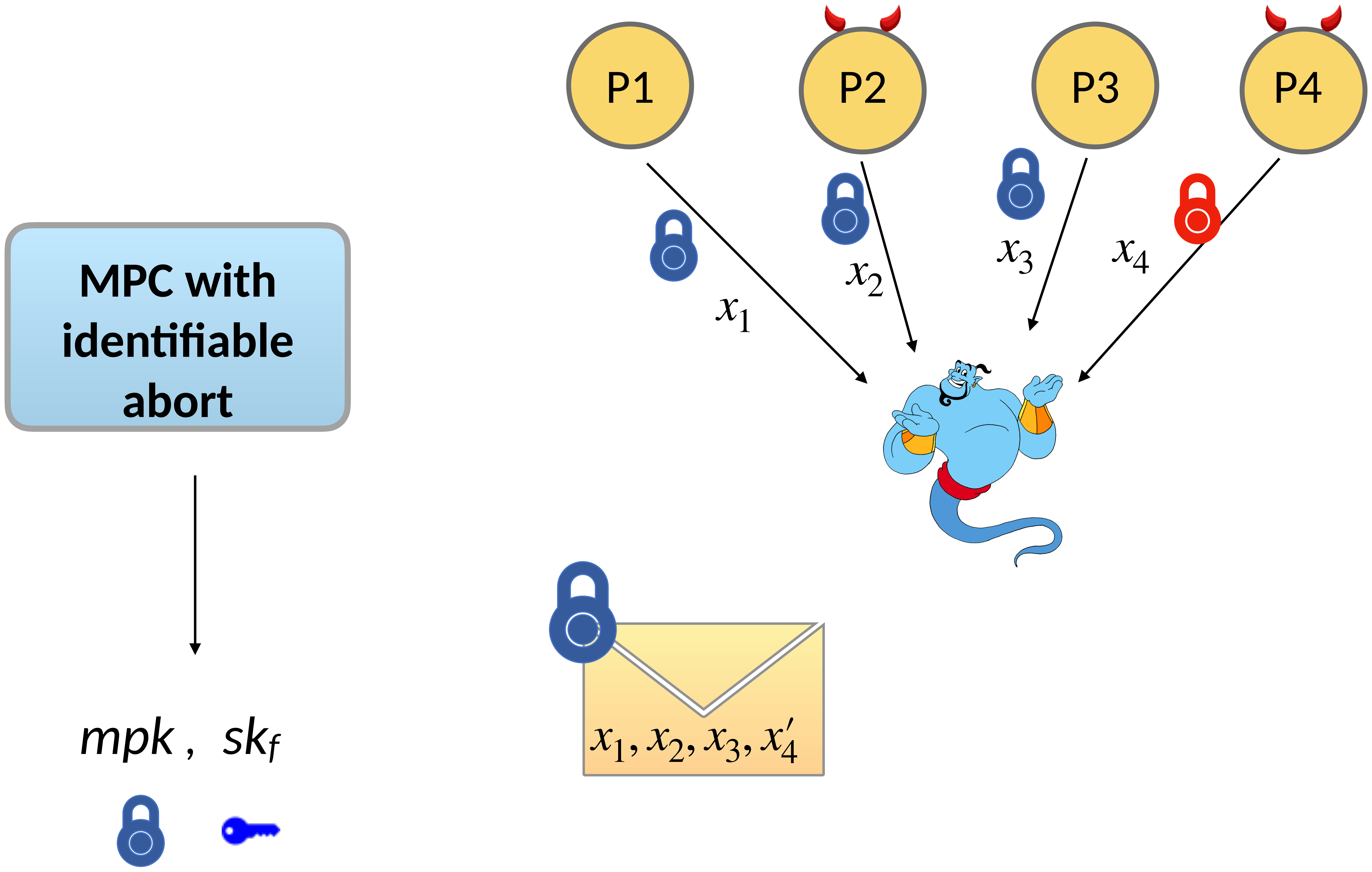

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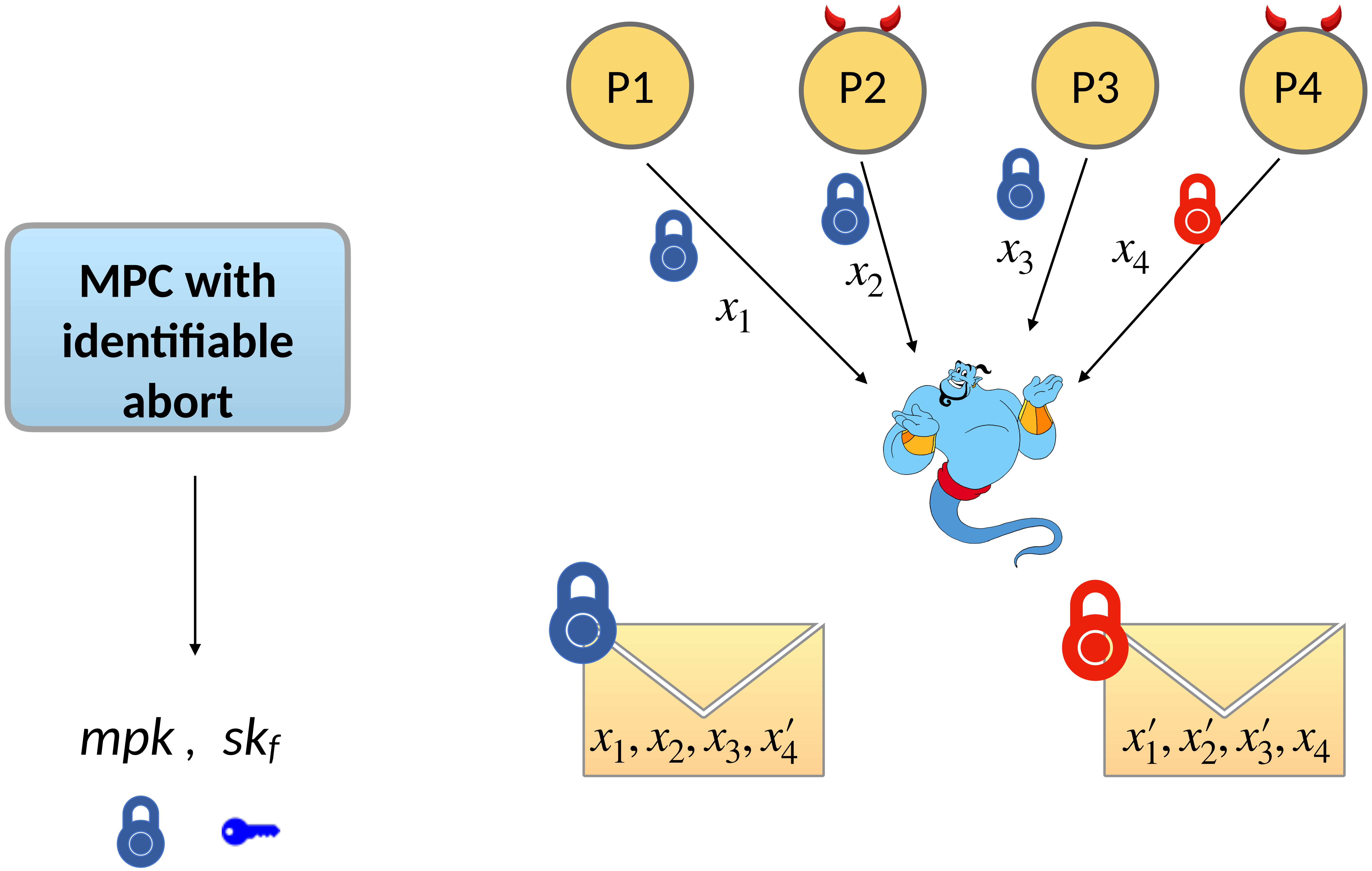

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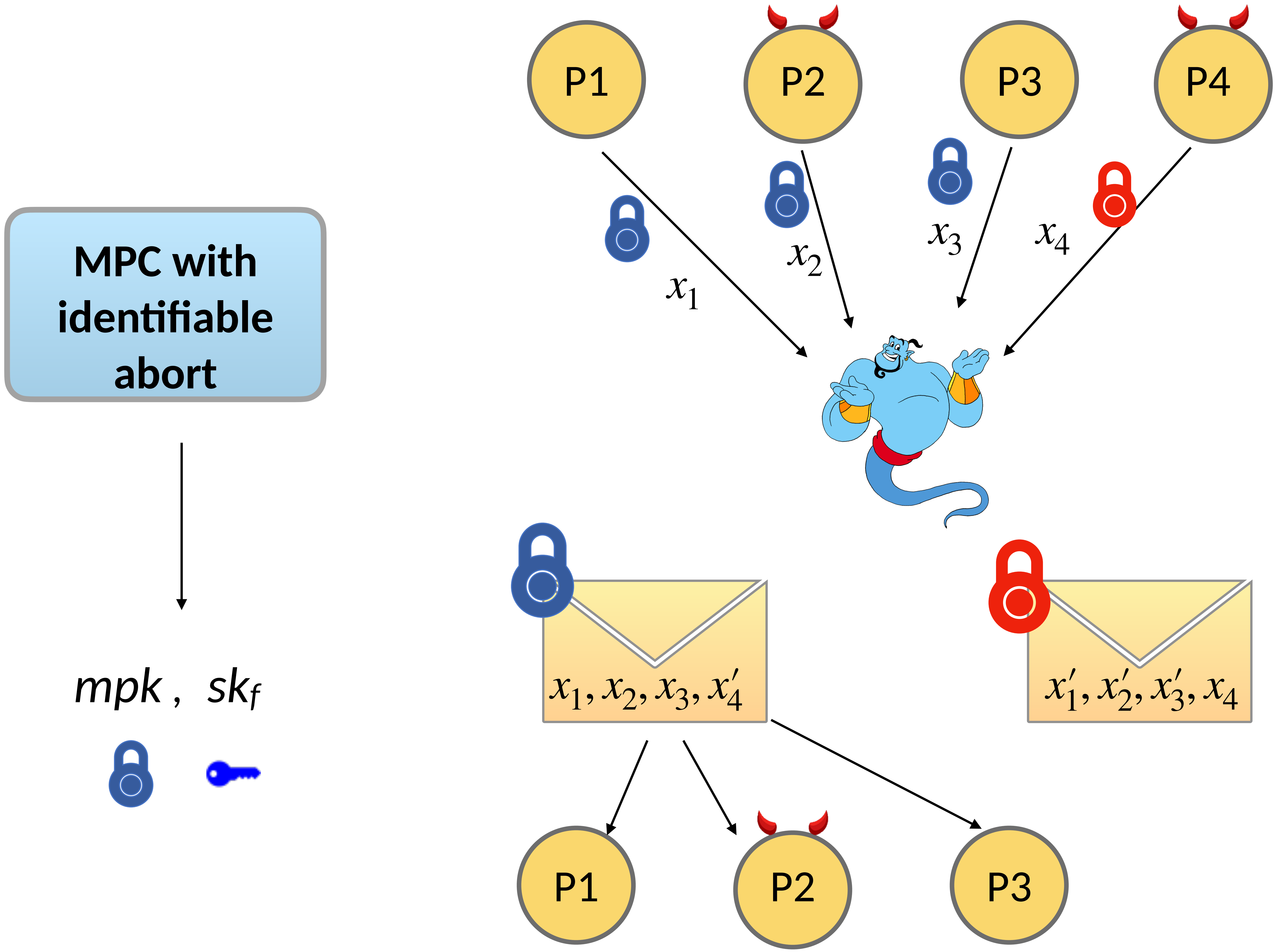

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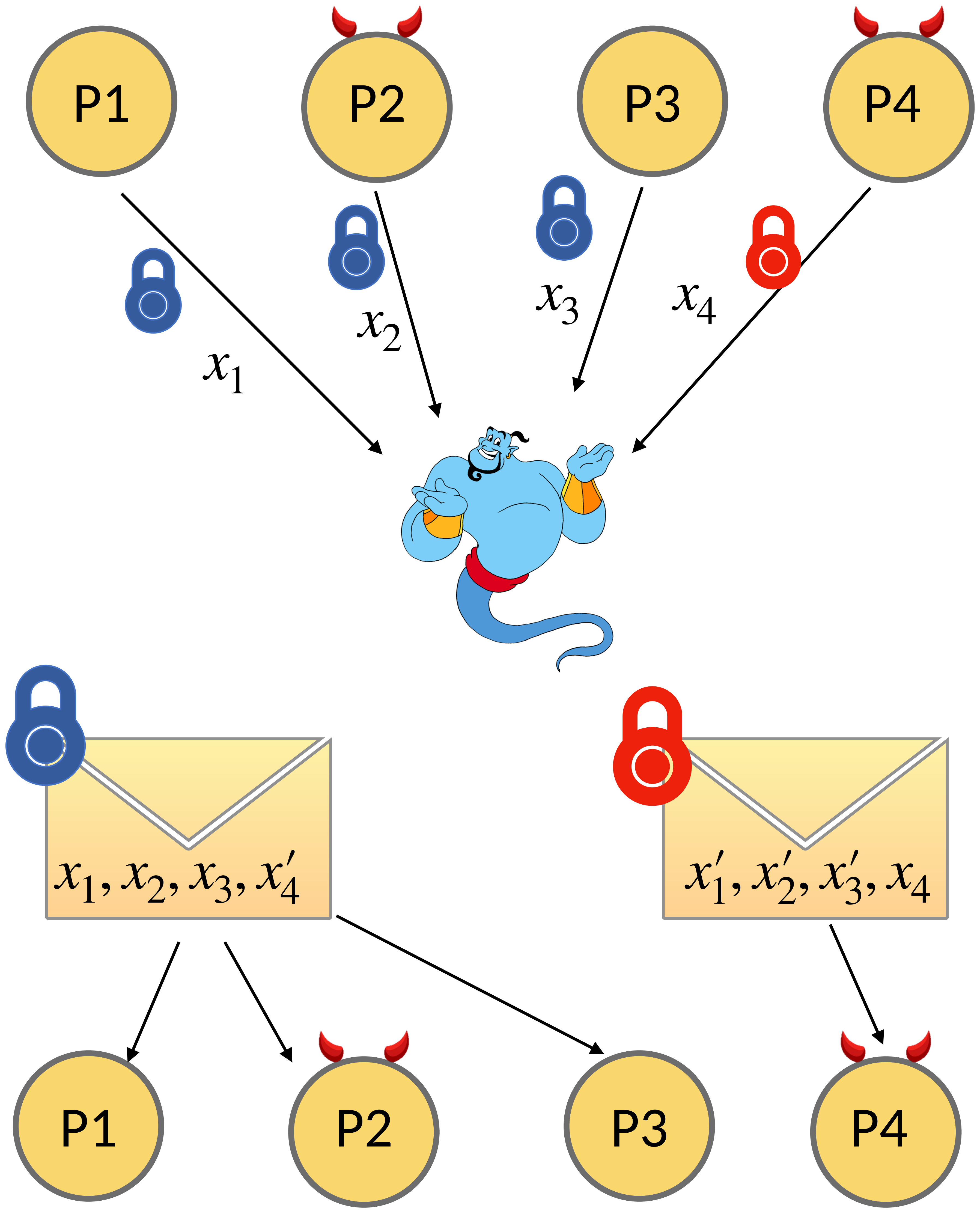

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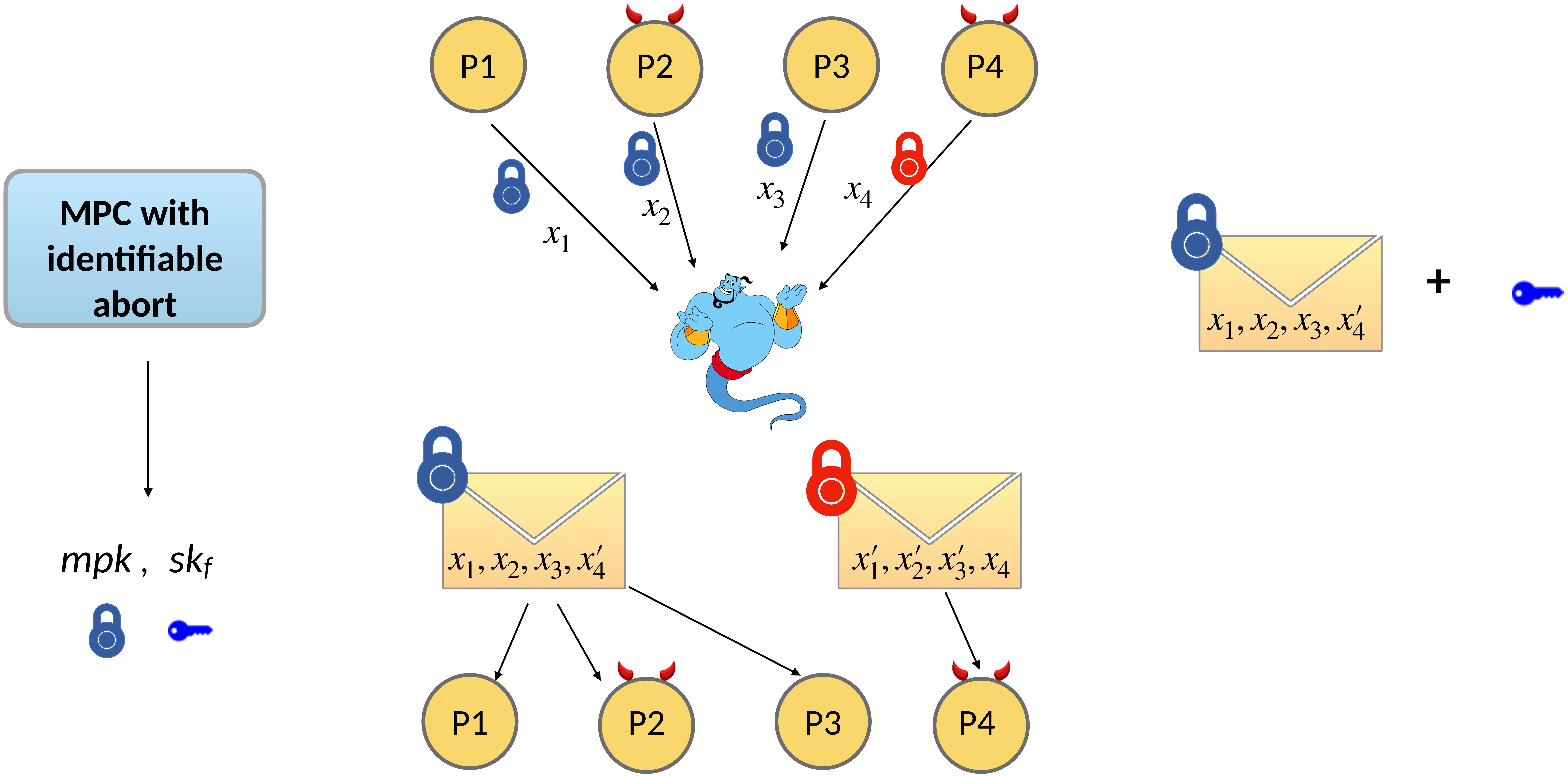

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P1 P2 P3 P4

x_1 x_2 x_3 x_4

x_1, x_2, x_3, x_4'

x_1', x_2', x_3', x_4

P1 P2 P3 P4

x_1, x_2, x_3, x_4' +

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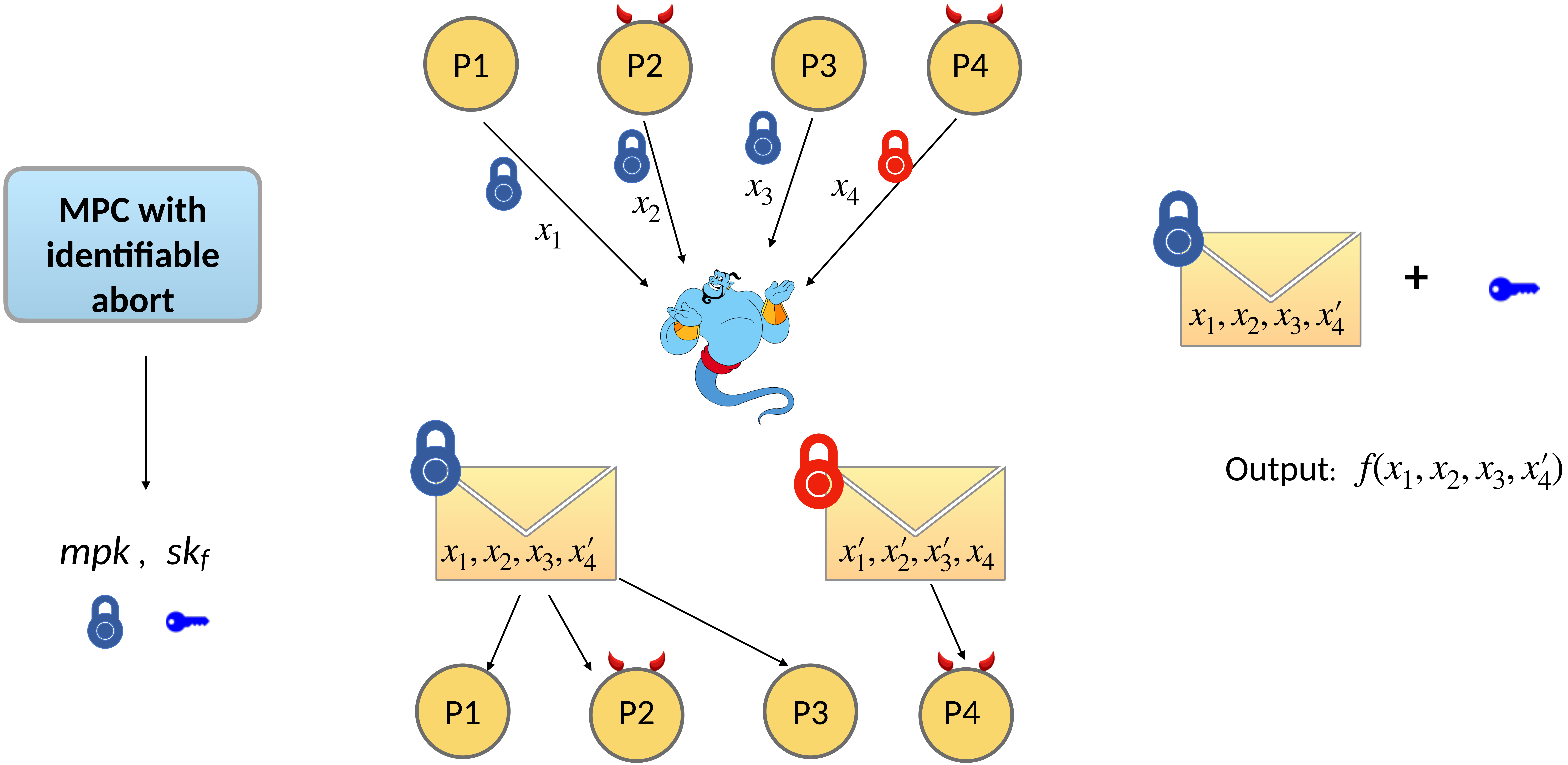

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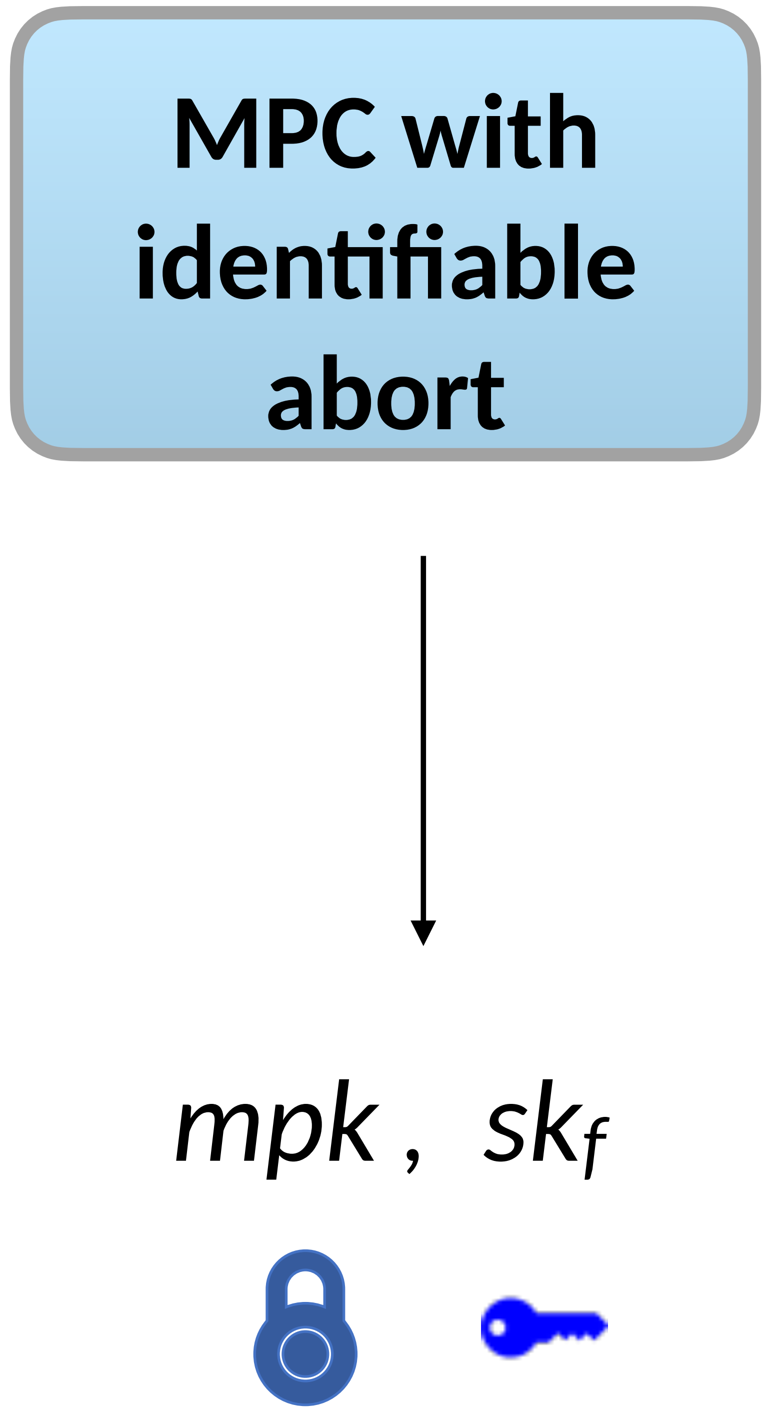

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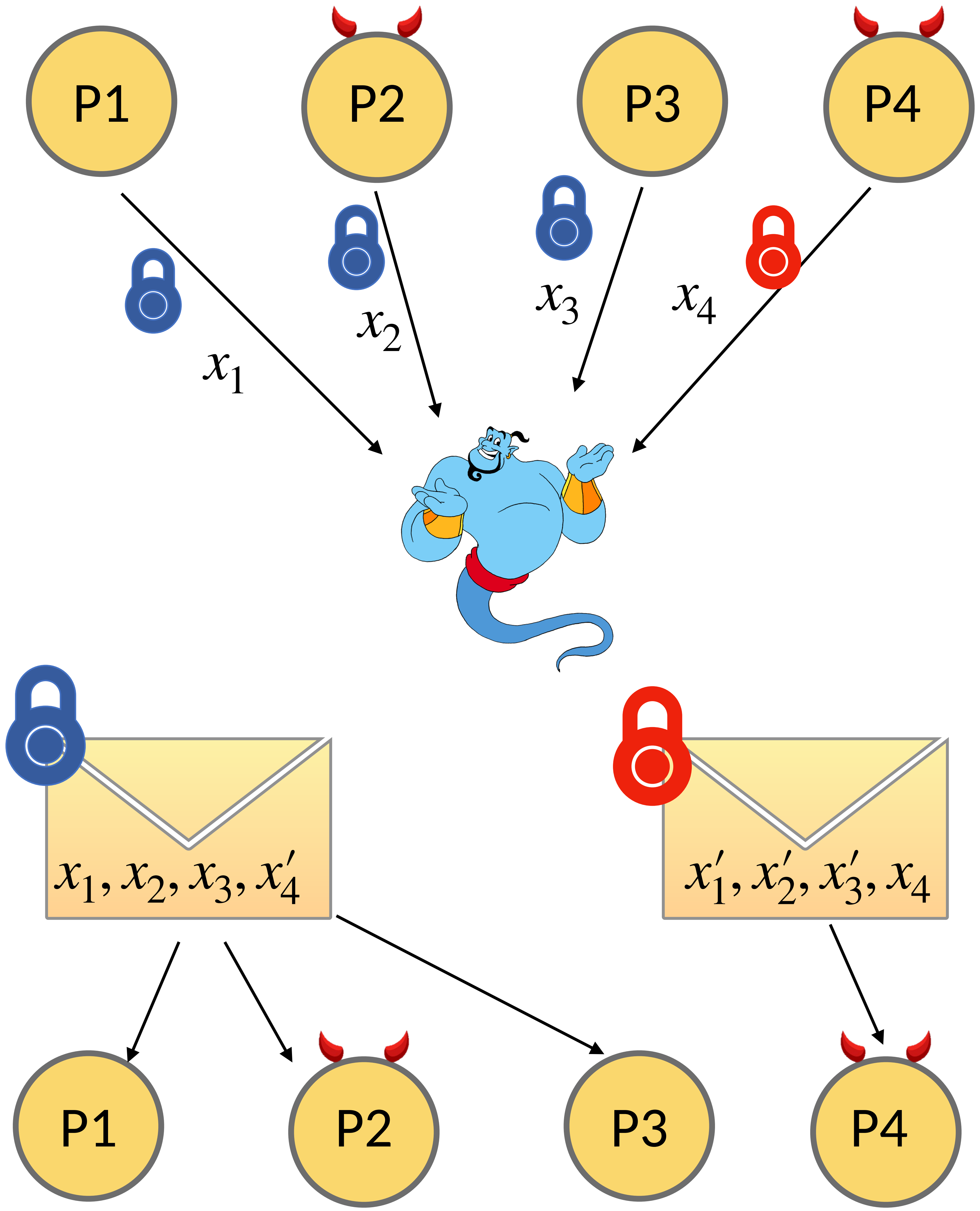
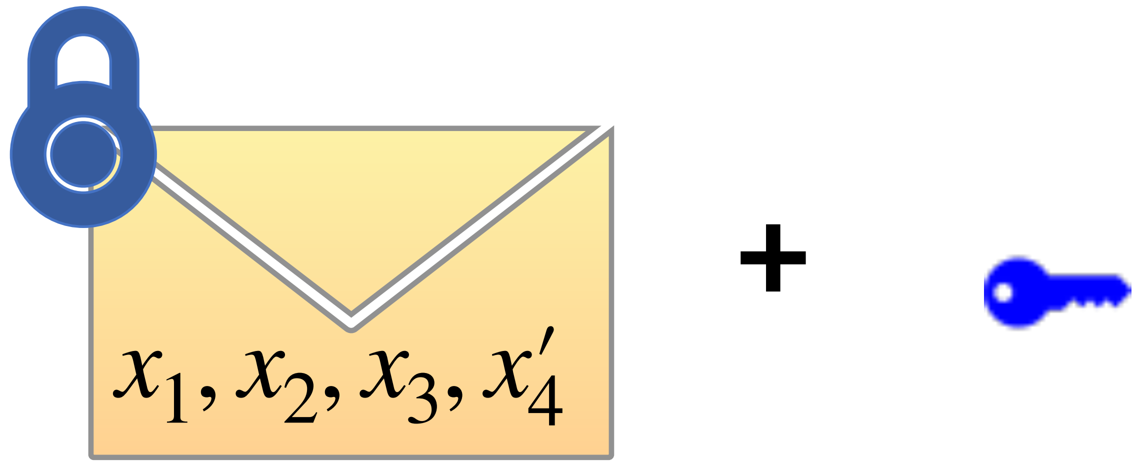


Size: poly(n, λ, d) (sub-exp LWE)

Size: poly(n, λ) (iO)



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Semi-Honest TP ?

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Dishonest Majority of active corruptions

AND

Semi-honest TP

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Colluding Model

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Fairness impossible!

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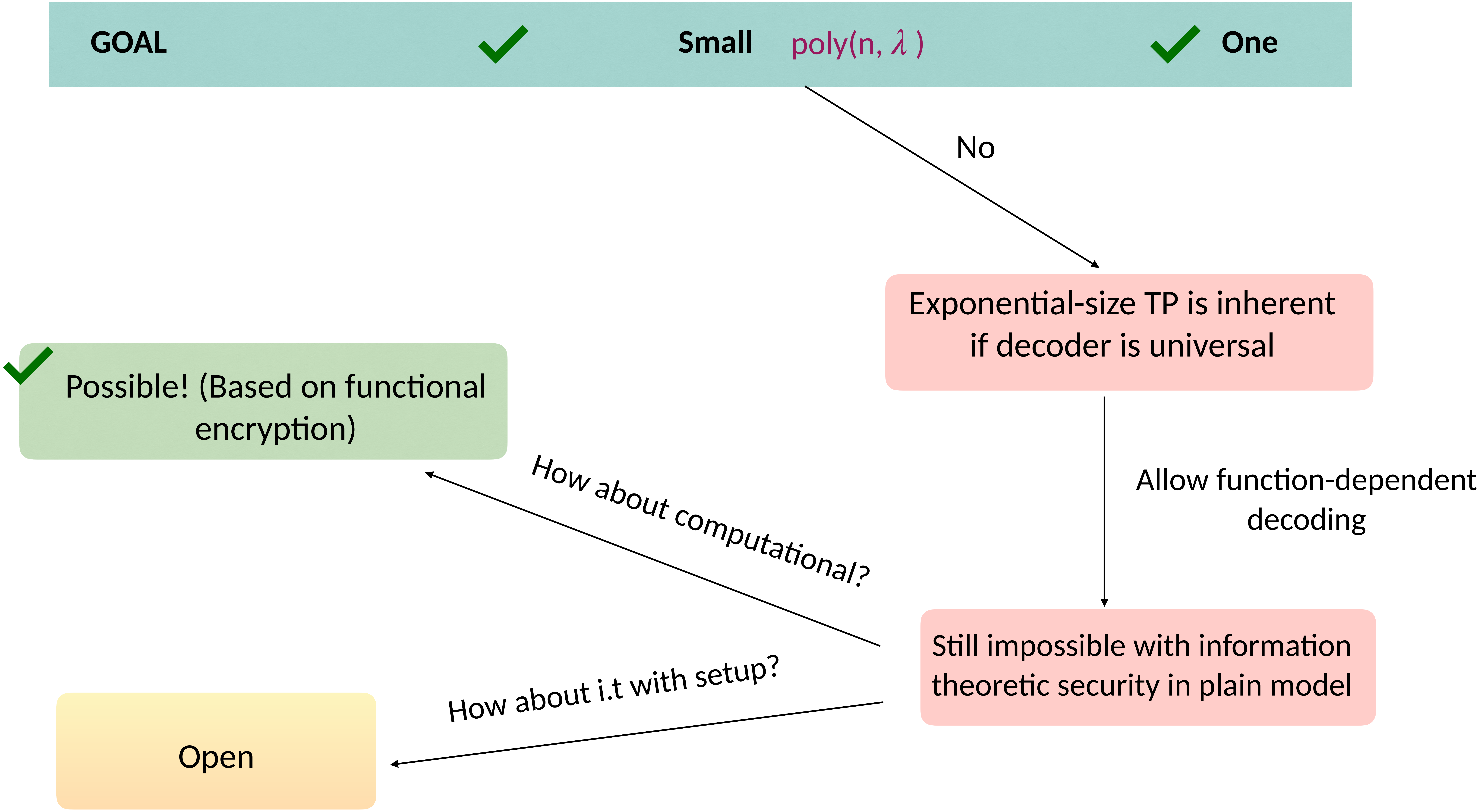
FE-Based construction works! (With tweaks)



GOAL ✓ **Small** poly(n, λ) ✓ **One**

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Exponential-size TP is inherent if decoder is universal

Allow function-dependent decoding

Still impossible with information theoretic security in plain model

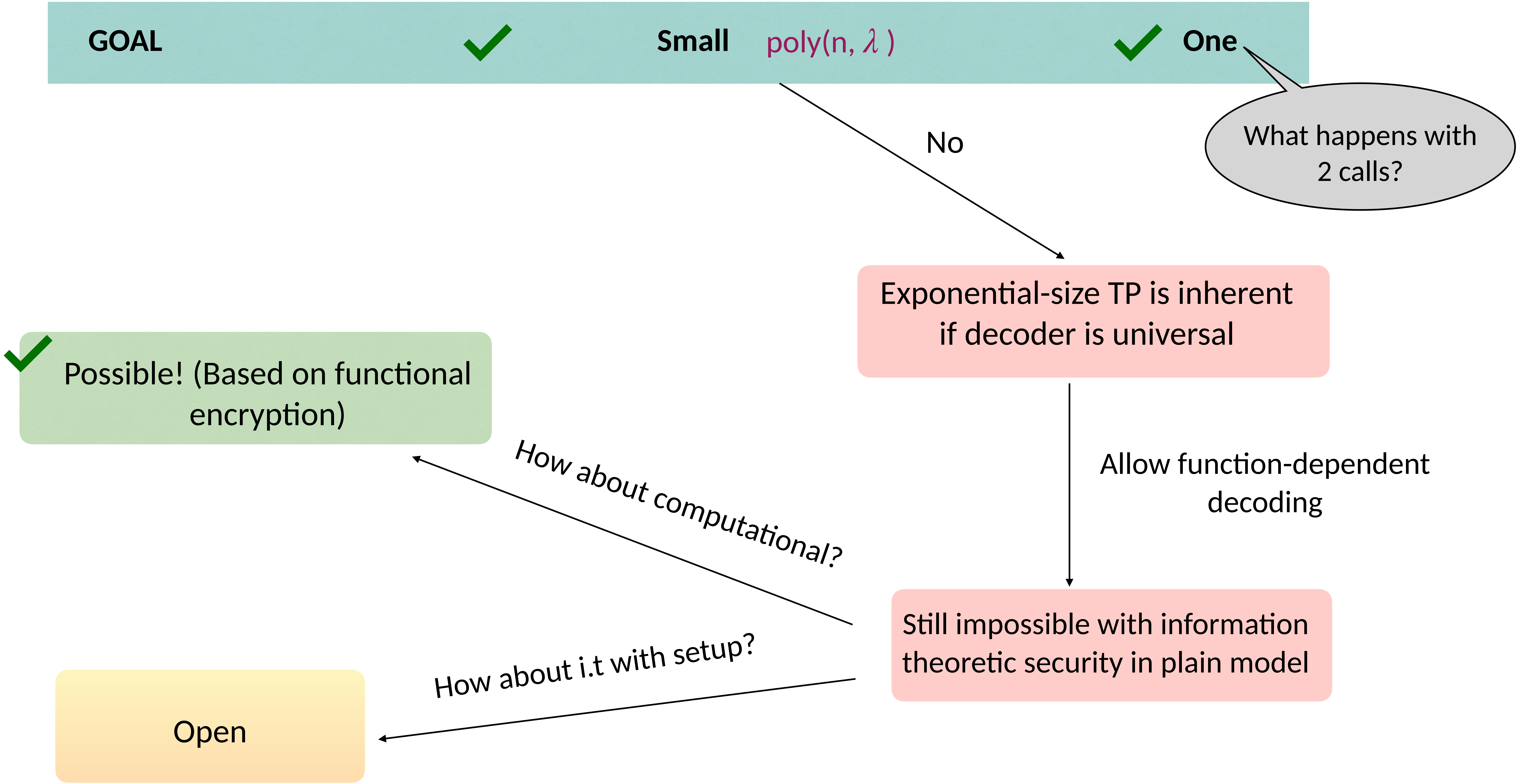
How about computational?

✓ Possible! (Based on functional encryption)

How about i.t with setup?

Open

Thank you :)



GOAL ✓ Small $\text{poly}(n, \lambda)$ ✓ One

What happens with 2 calls?

No

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Thank you :)