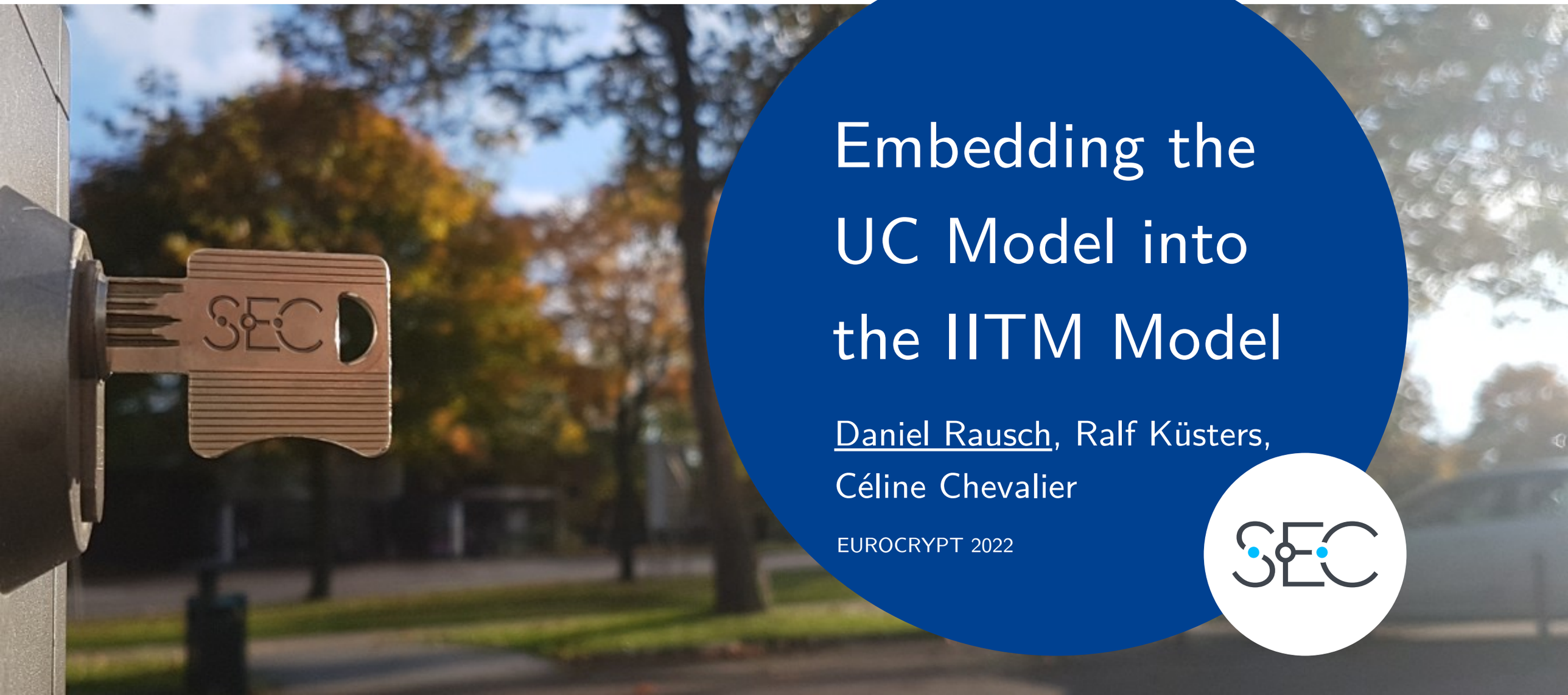
University of Stuttgart
Institute of
Information Security



Embedding the UC Model into the IITM Model

Daniel Rausch, Ralf Küsters,
Céline Chevalier

EUROCRYPT 2022

Universal Composability

Widely used concept for defining and analyzing protocol security:

- Strong security guarantees
- Composability via composition theorems
  - Modular analysis
  - Re-use results

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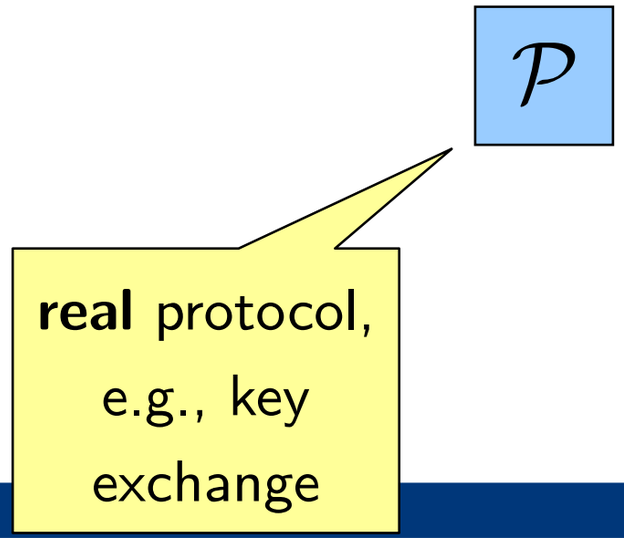

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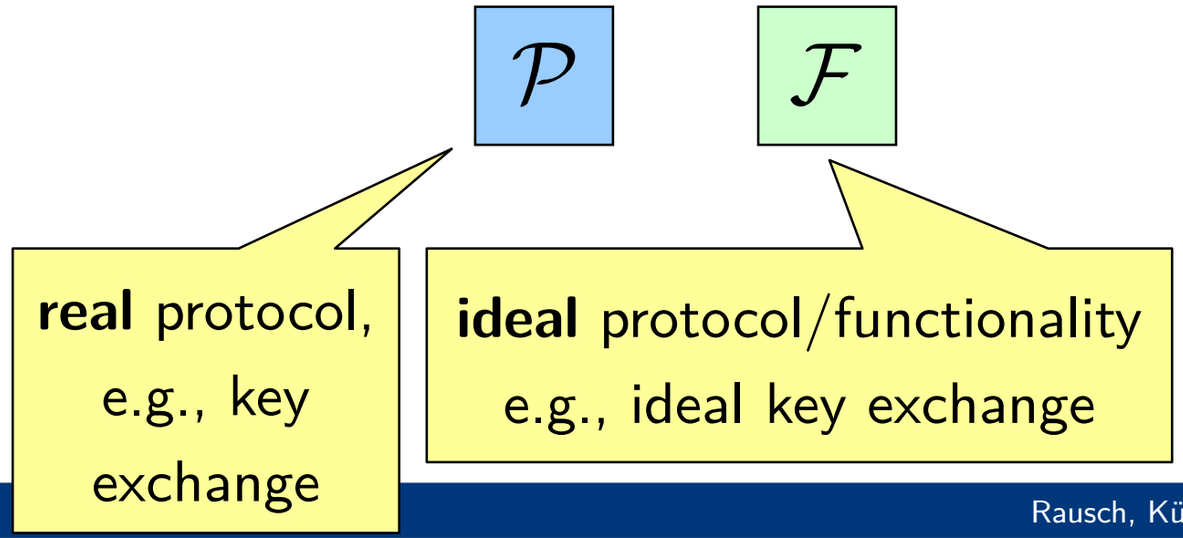

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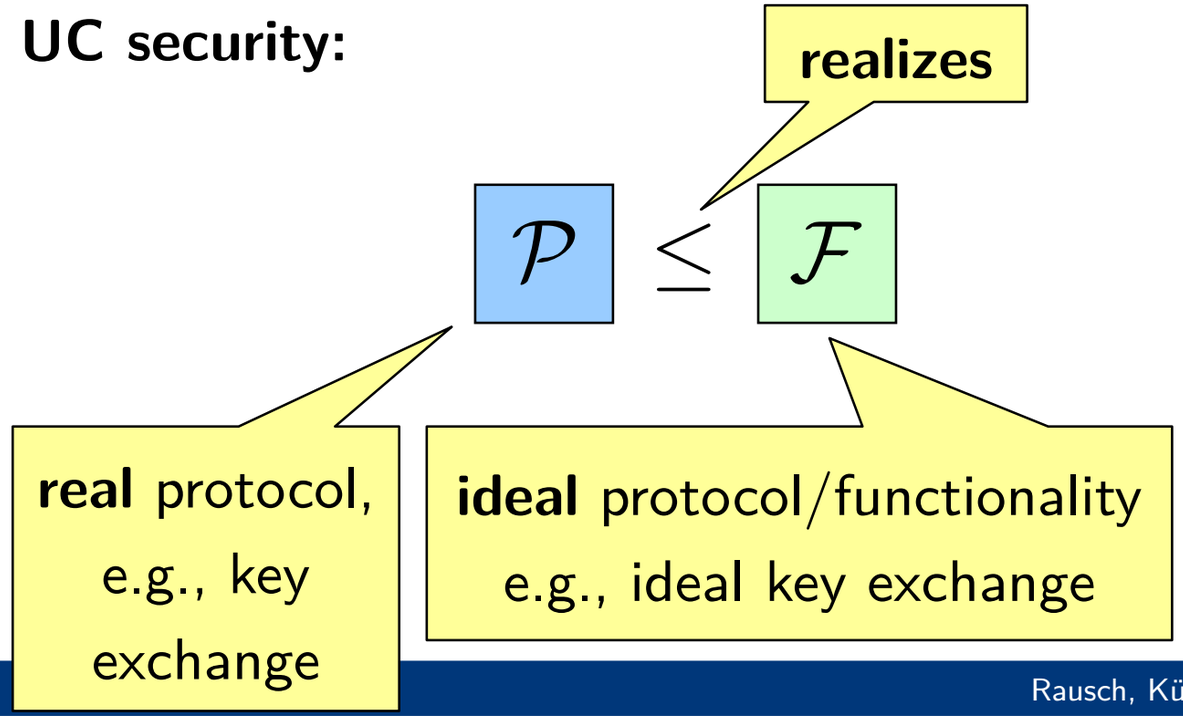

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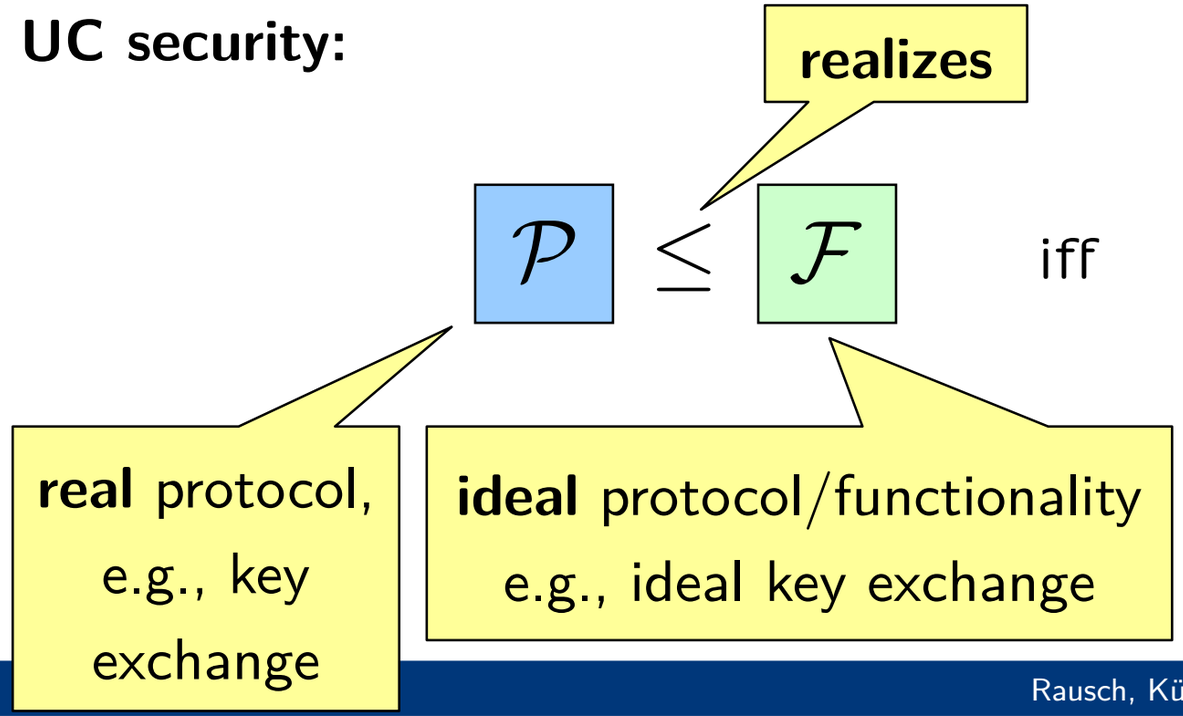

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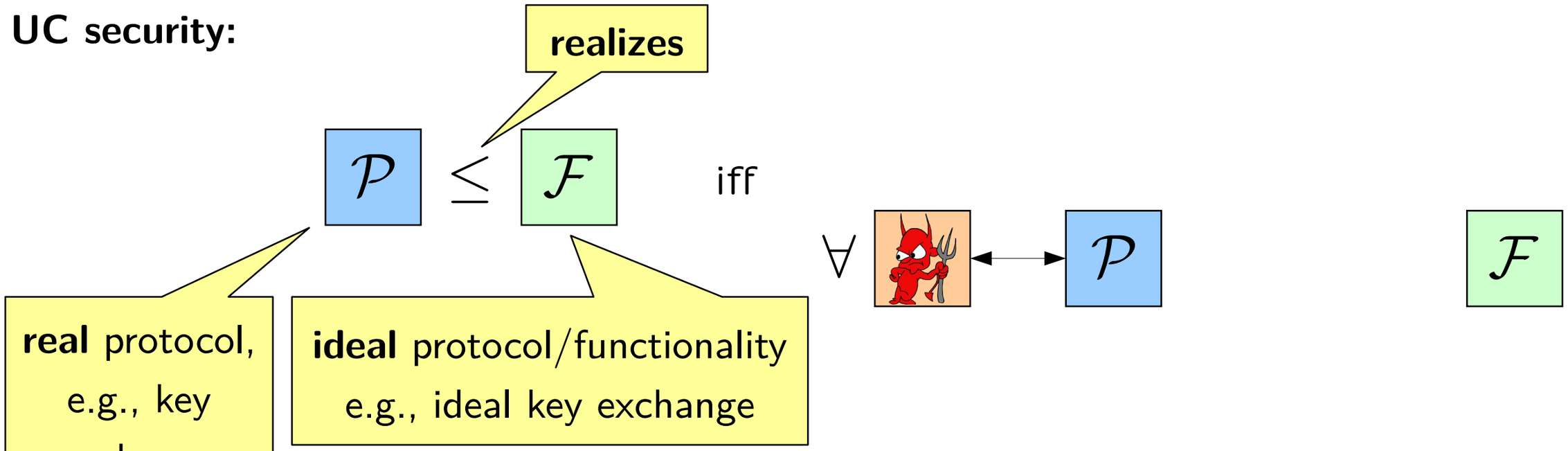

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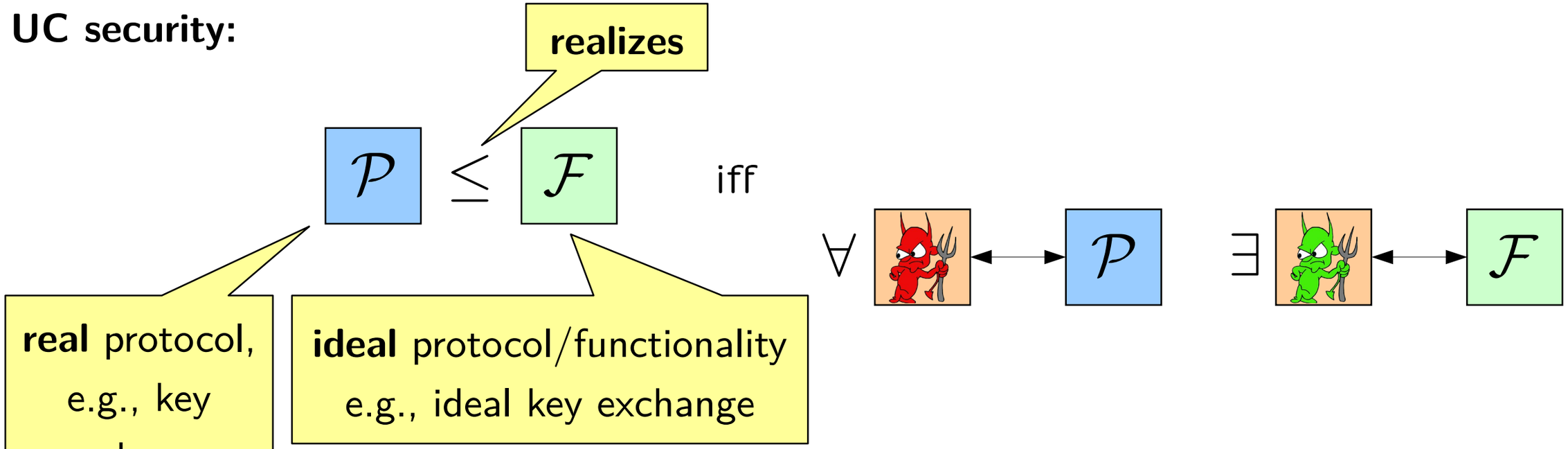

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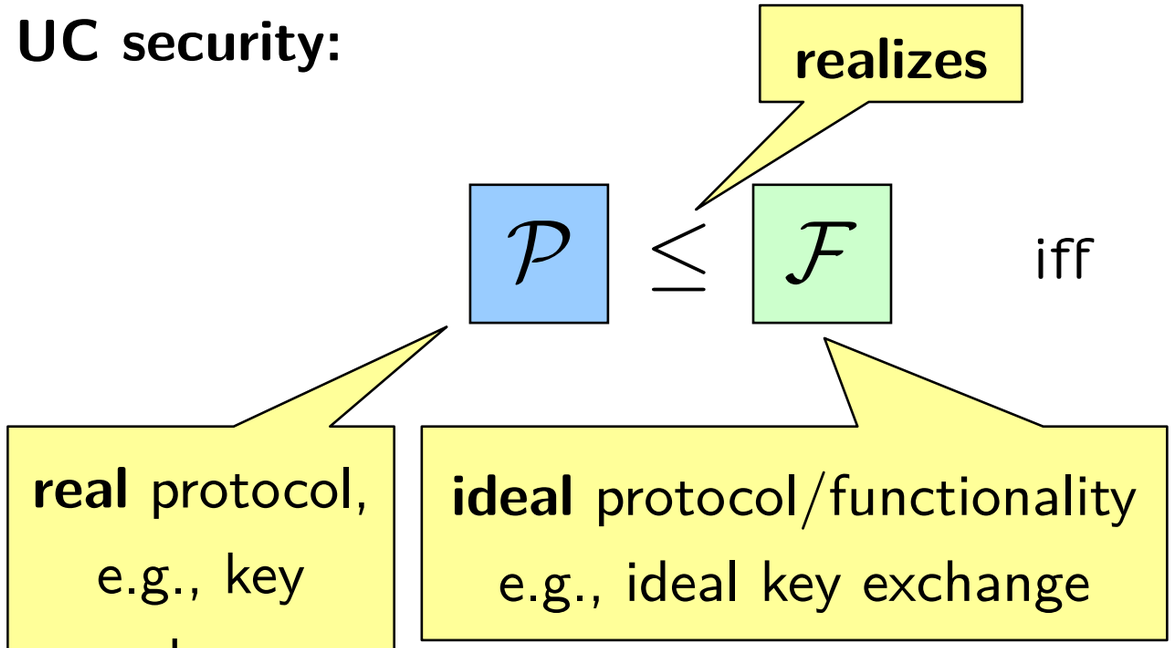

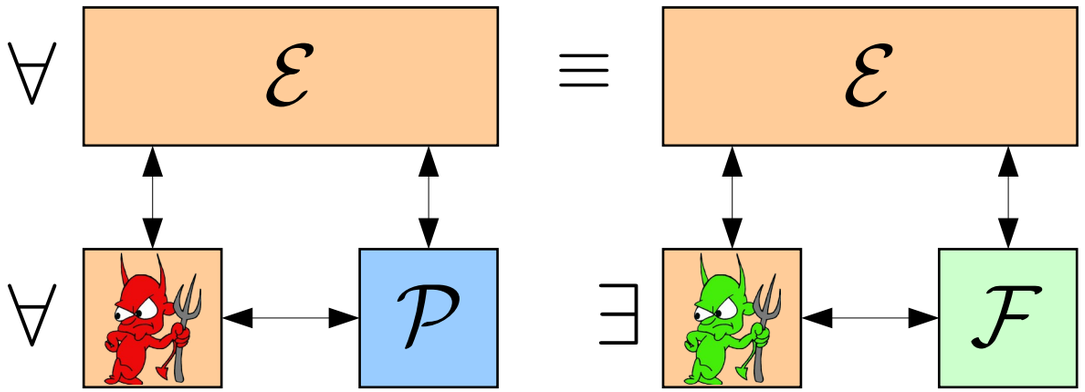

Models for Universal Composability

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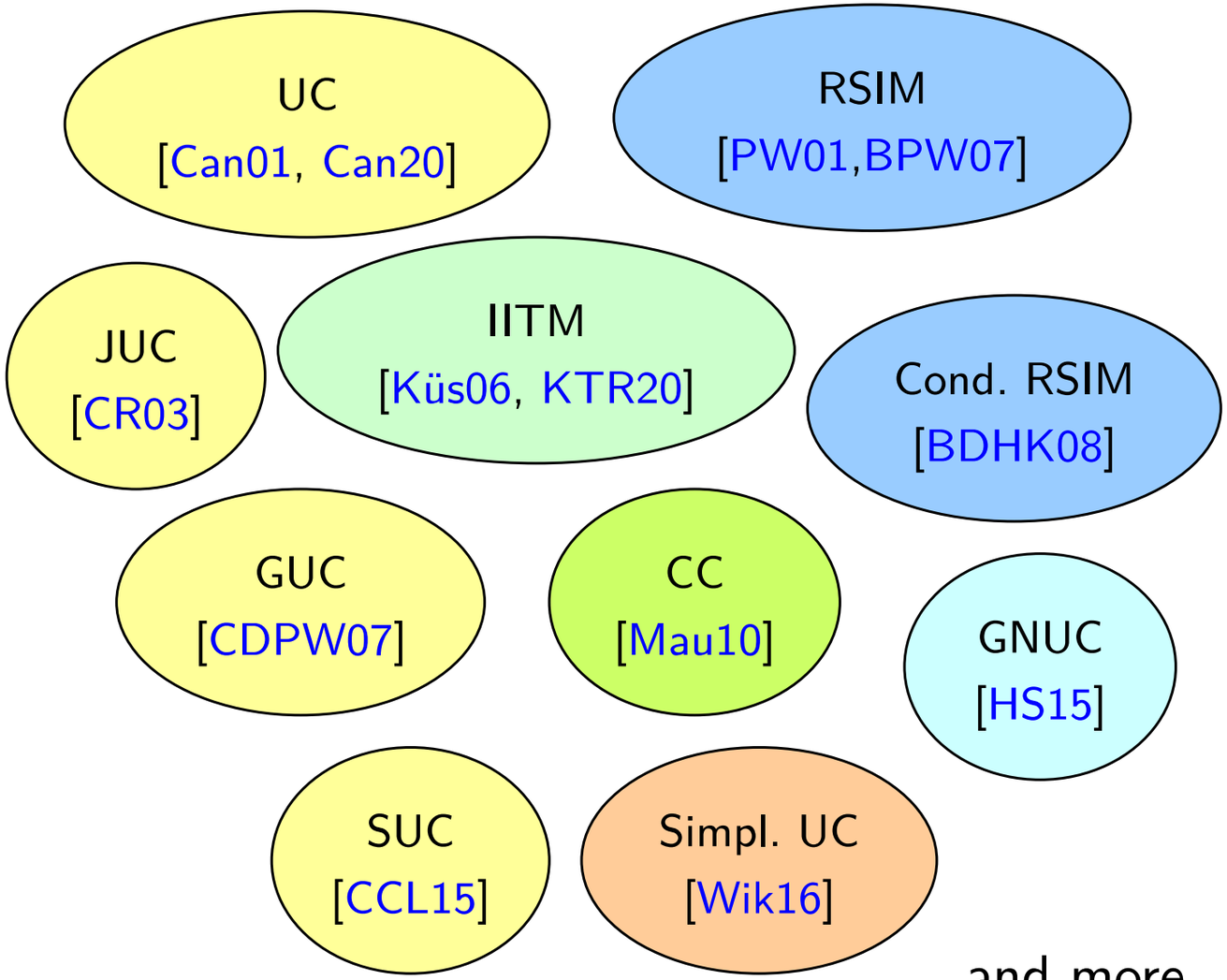

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Models for Universal Composability

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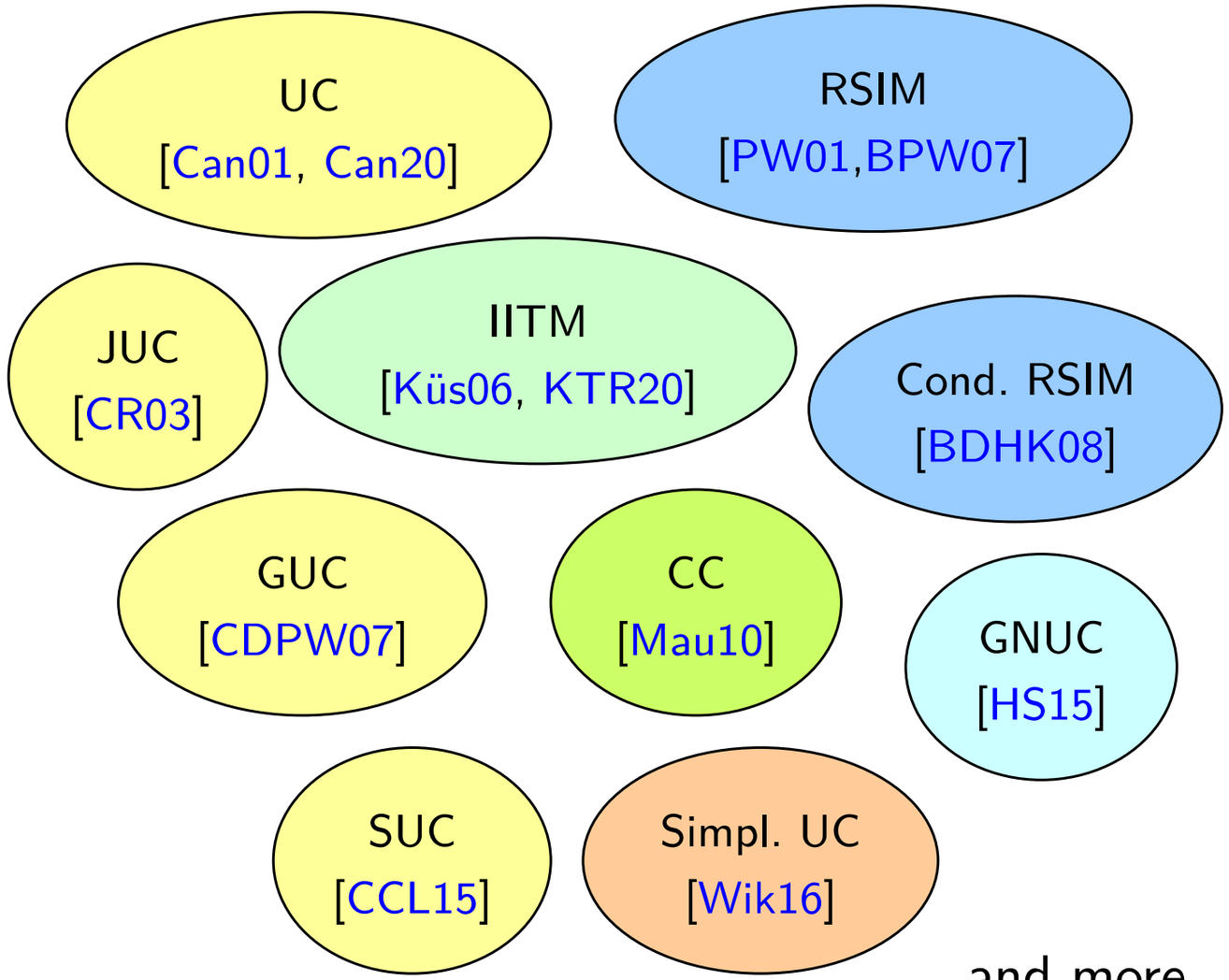

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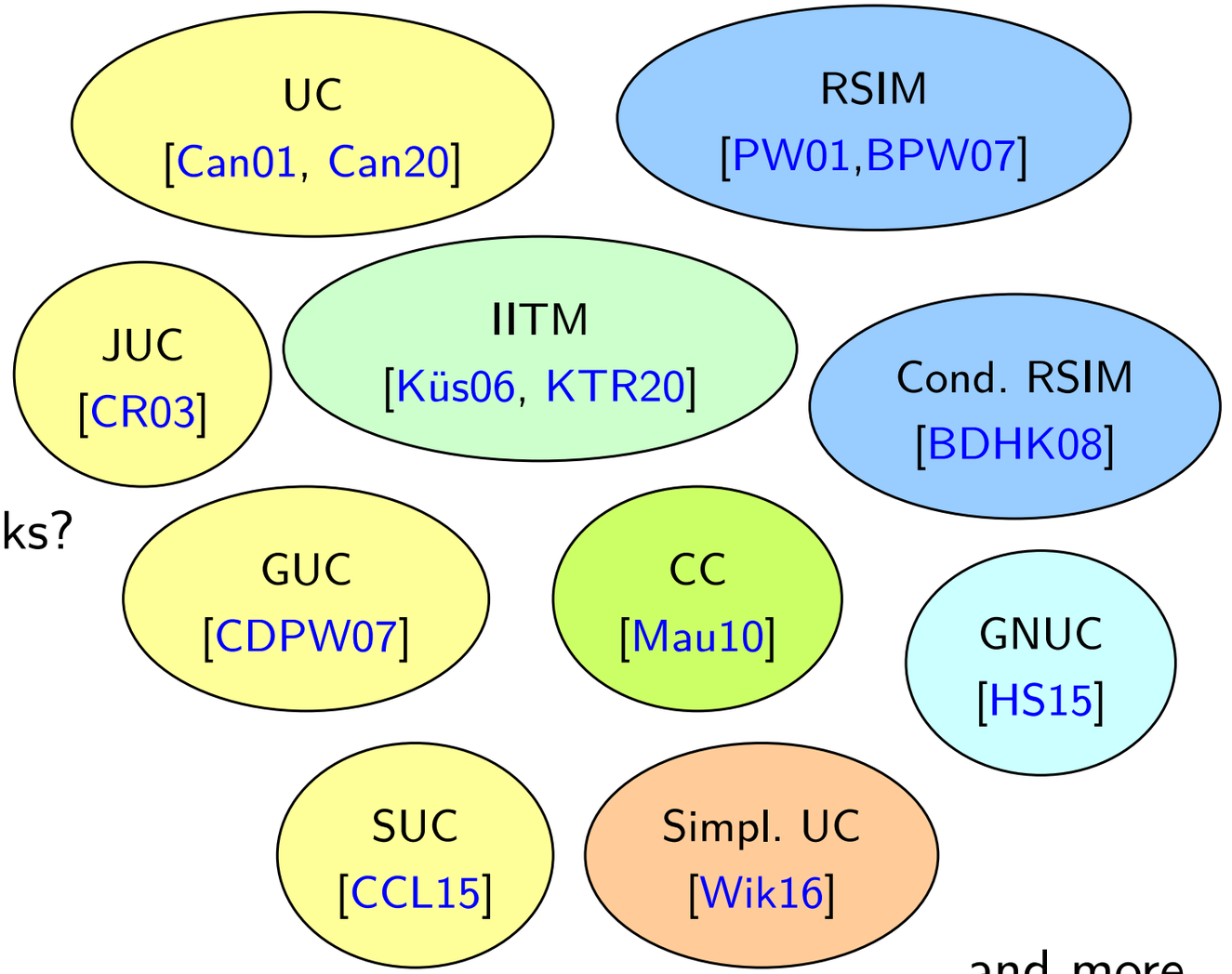

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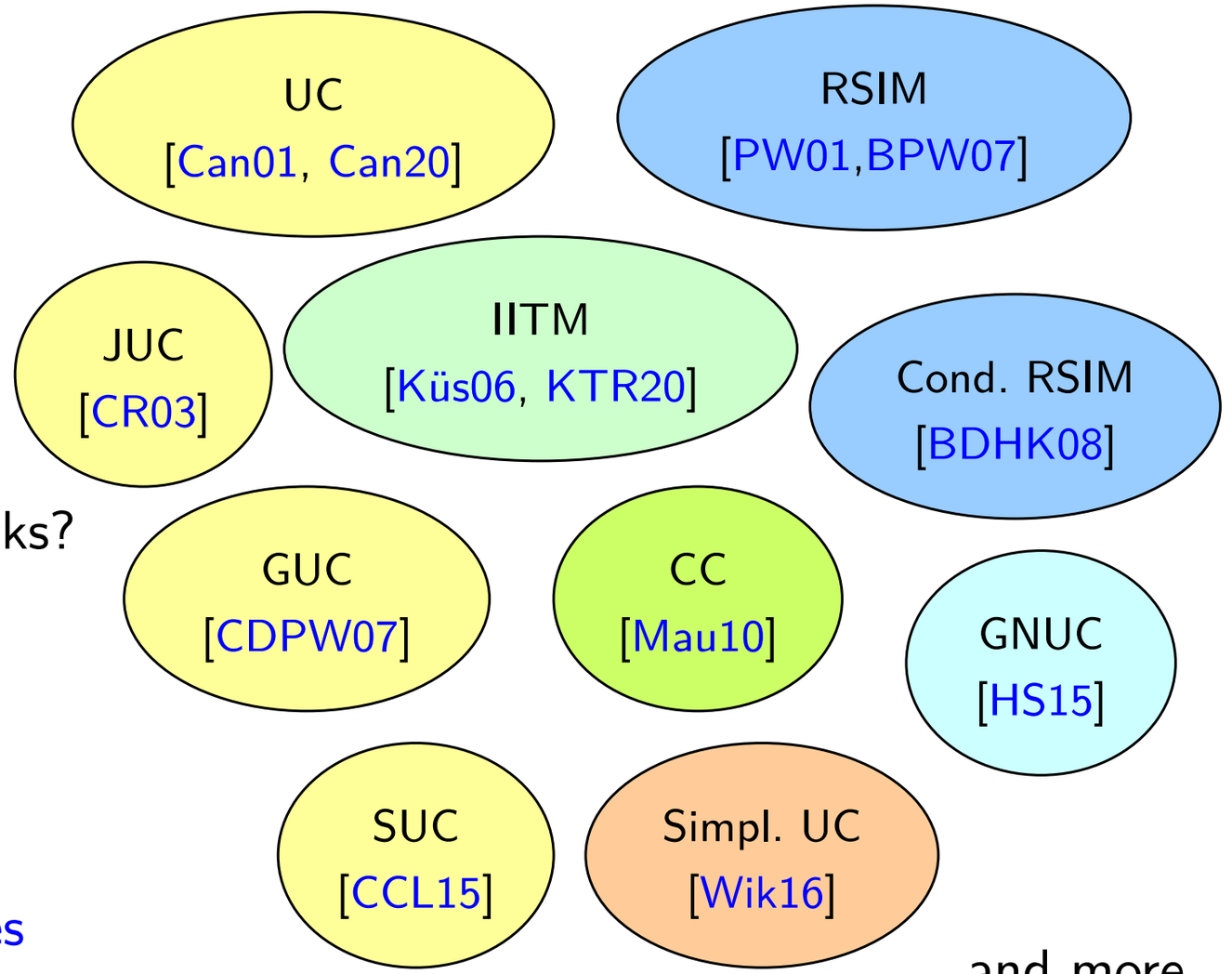
→ Map and re-use protocols, results, features from one model to others



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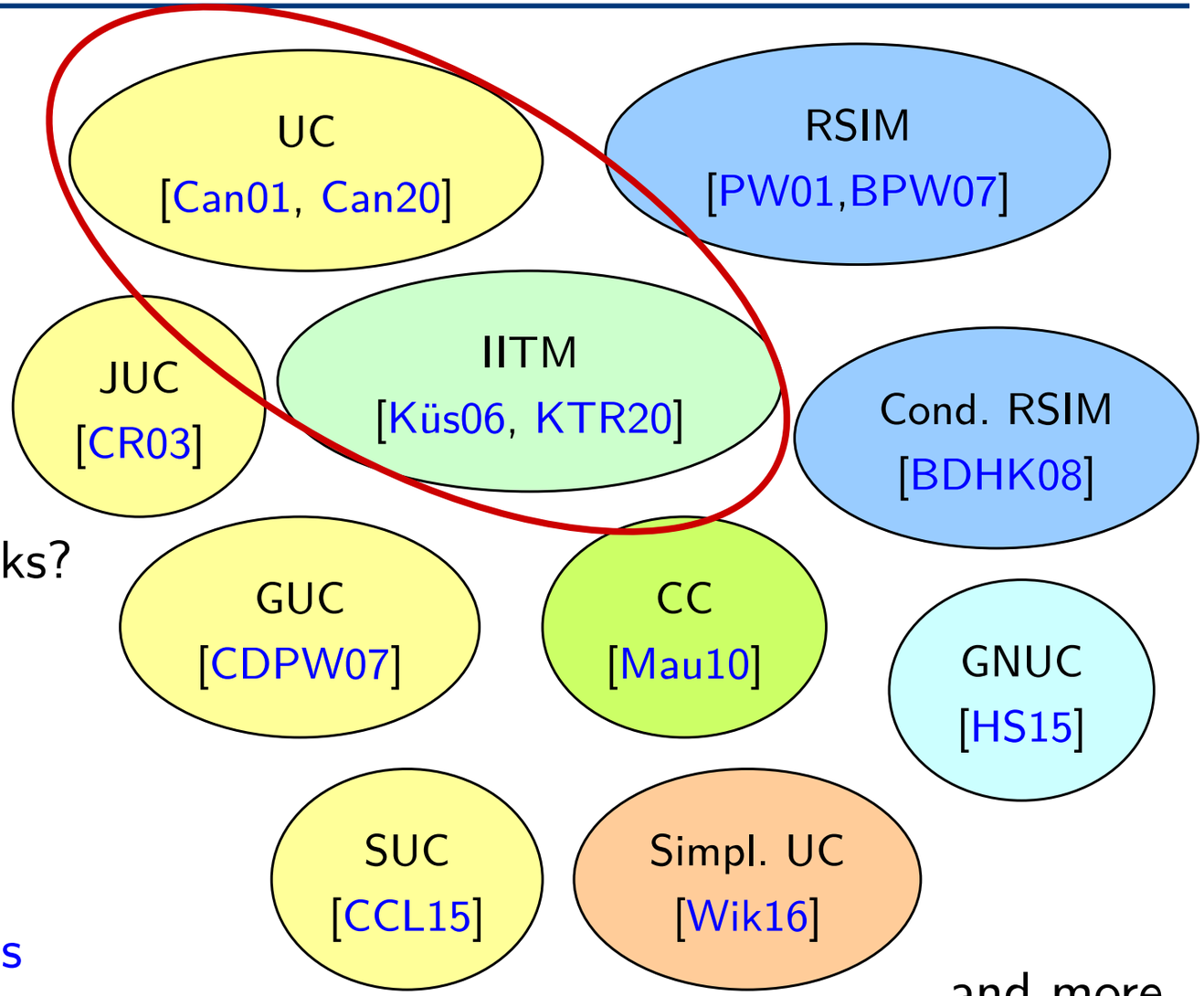
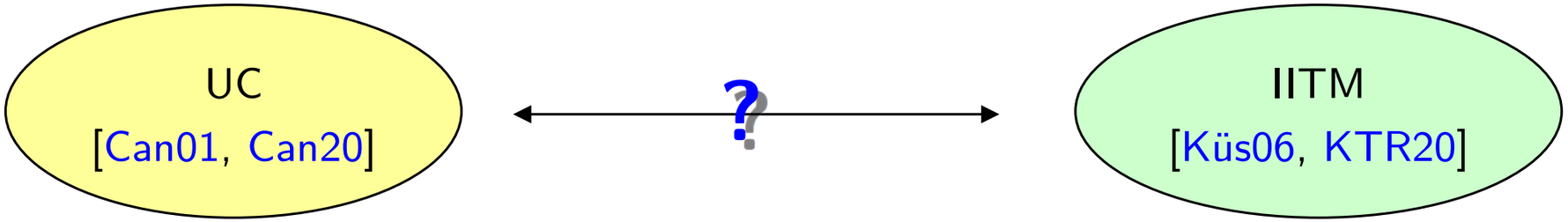


Why UC and IITM?



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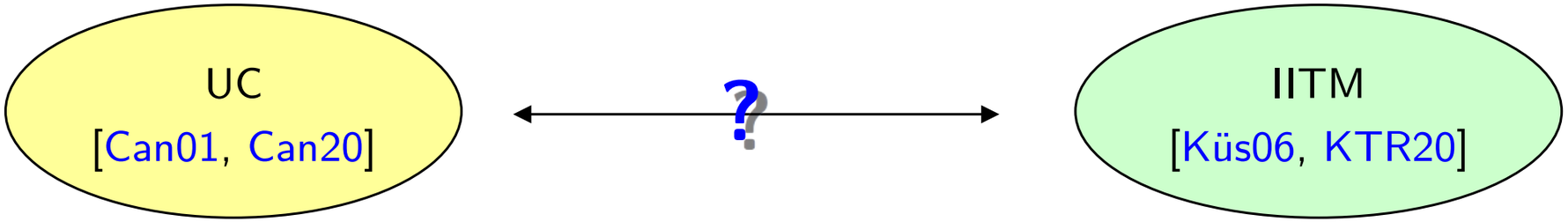

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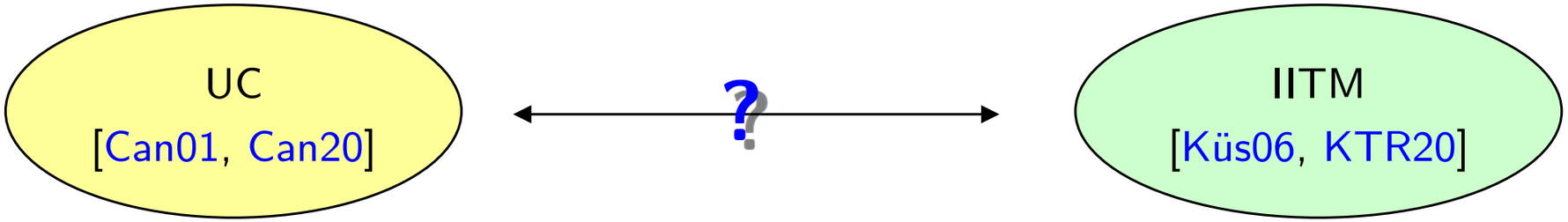

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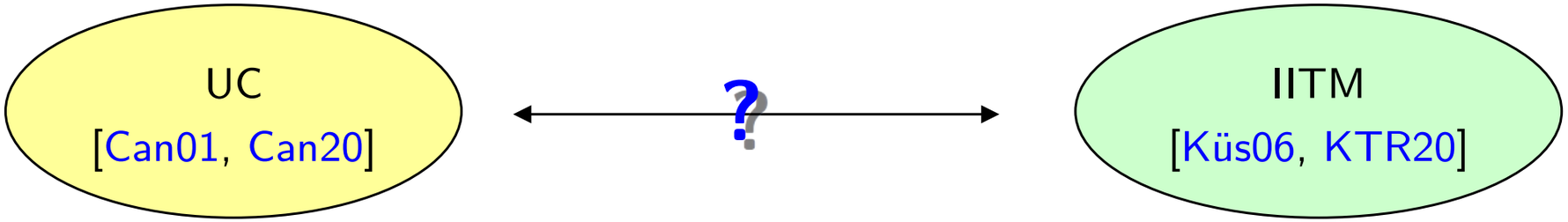

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Overview of Our Contributions

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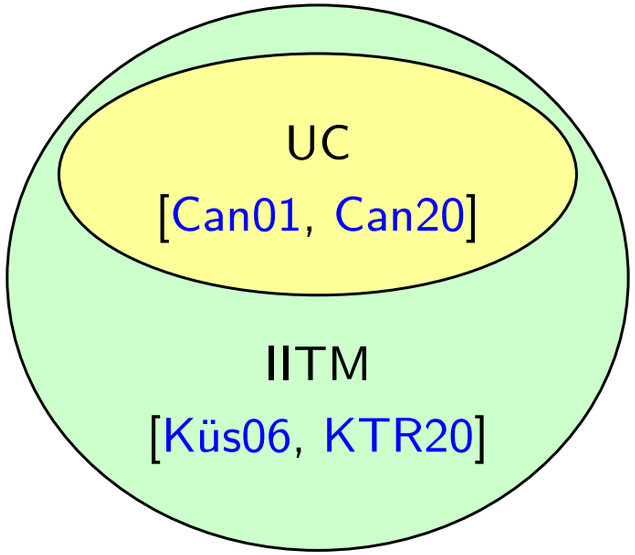

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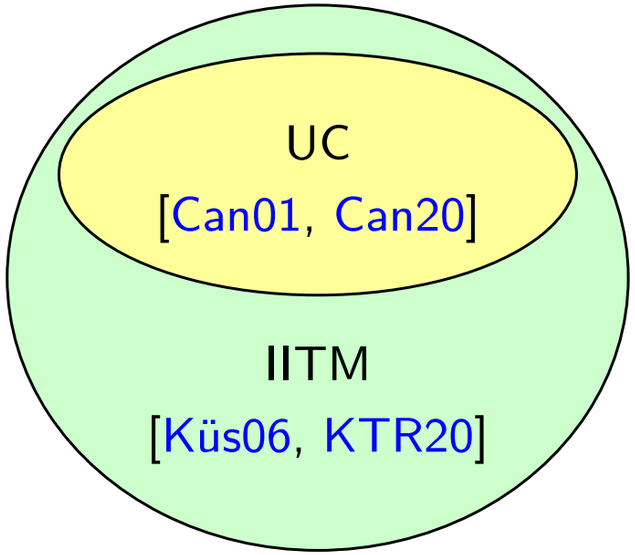

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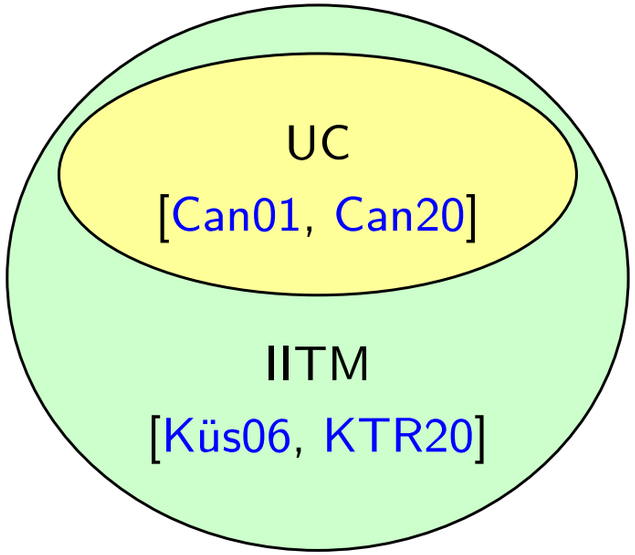

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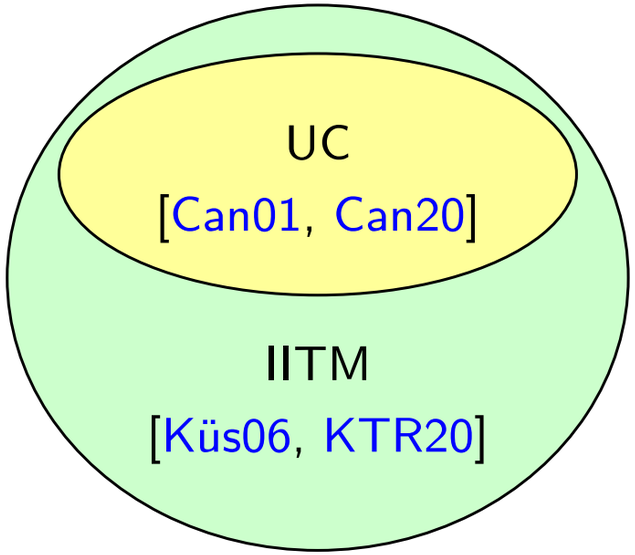

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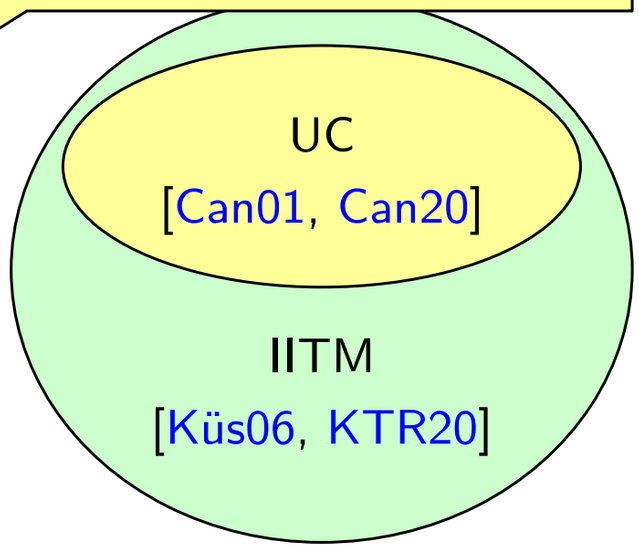

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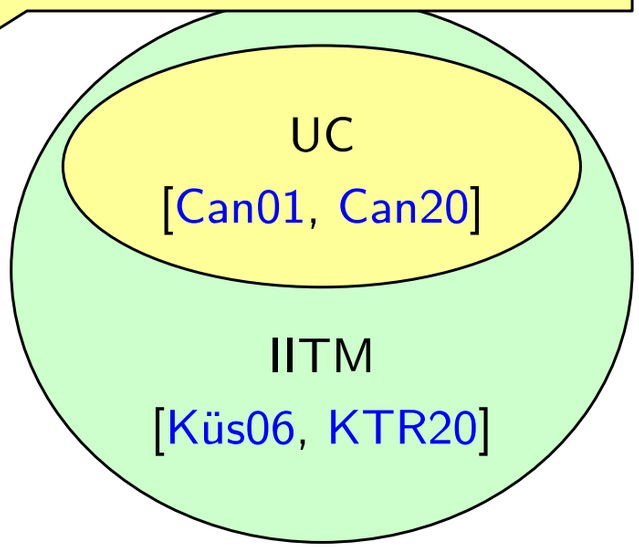

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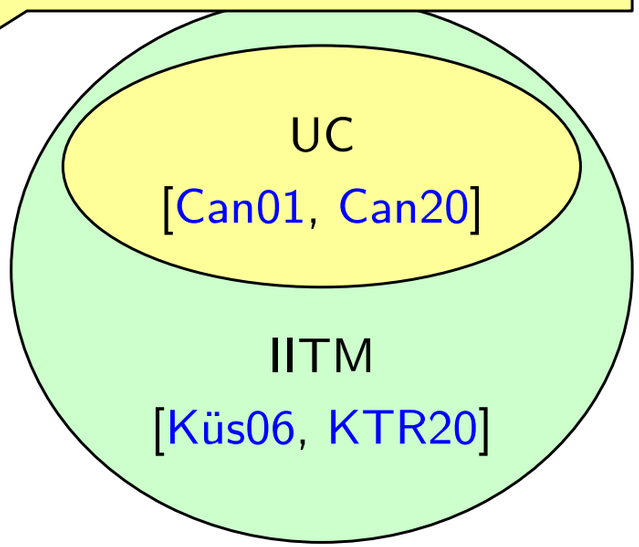

Further results (details in the paper):

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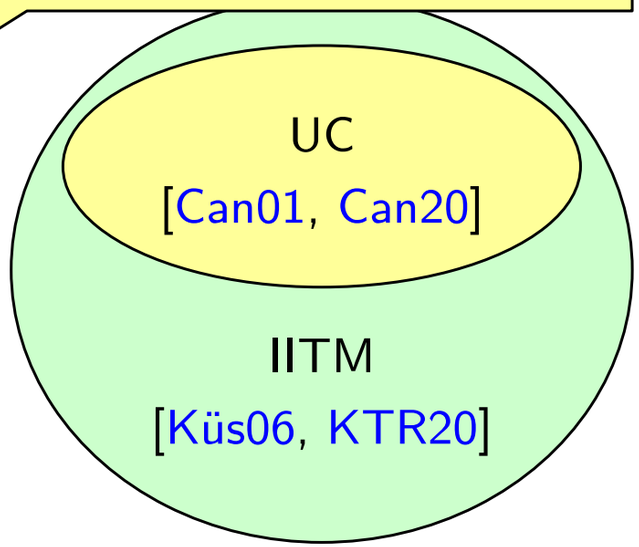

Further results (details in the paper):

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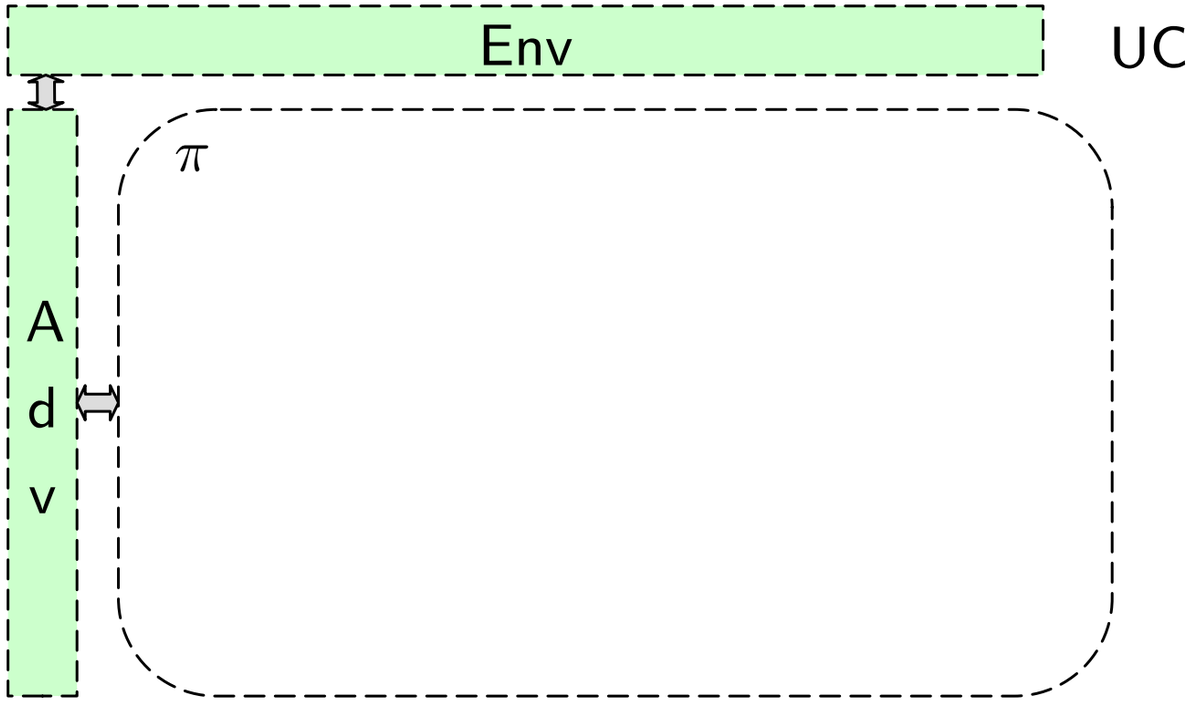
- Modeling technique for a new type of composition

Main Contributions

- **Concepts of UC and IITM**
- Embedding UC into IITM
- The Other Direction

Example: Computational Framework



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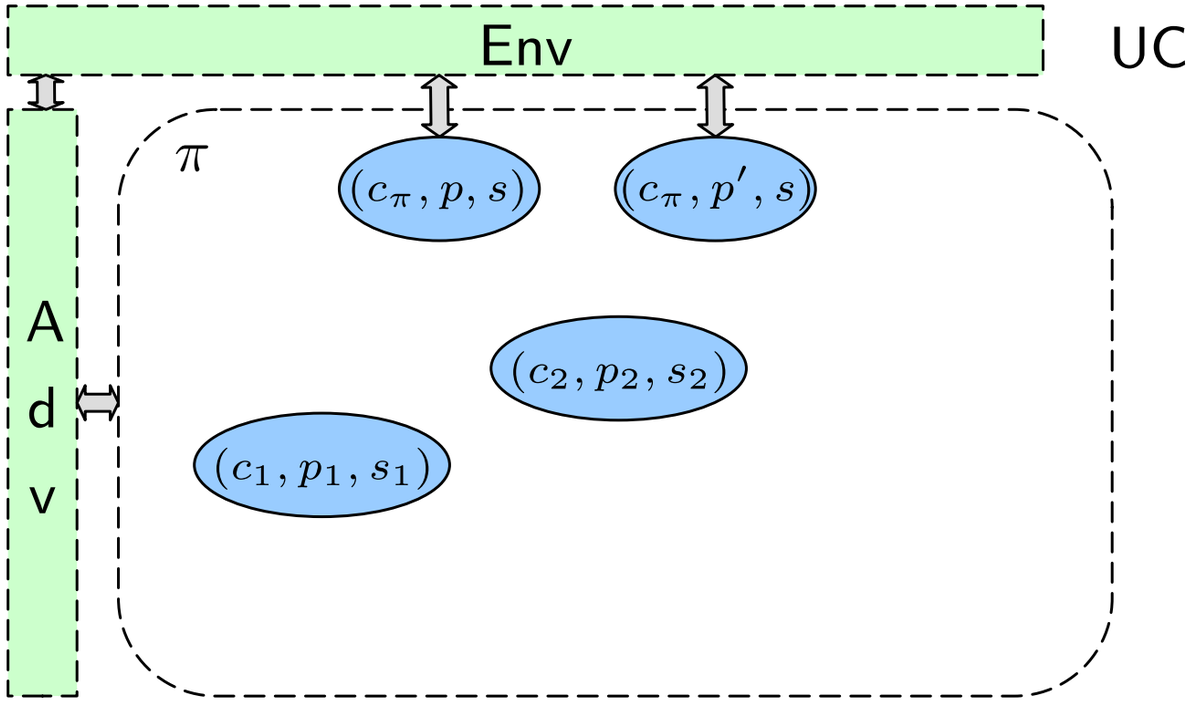

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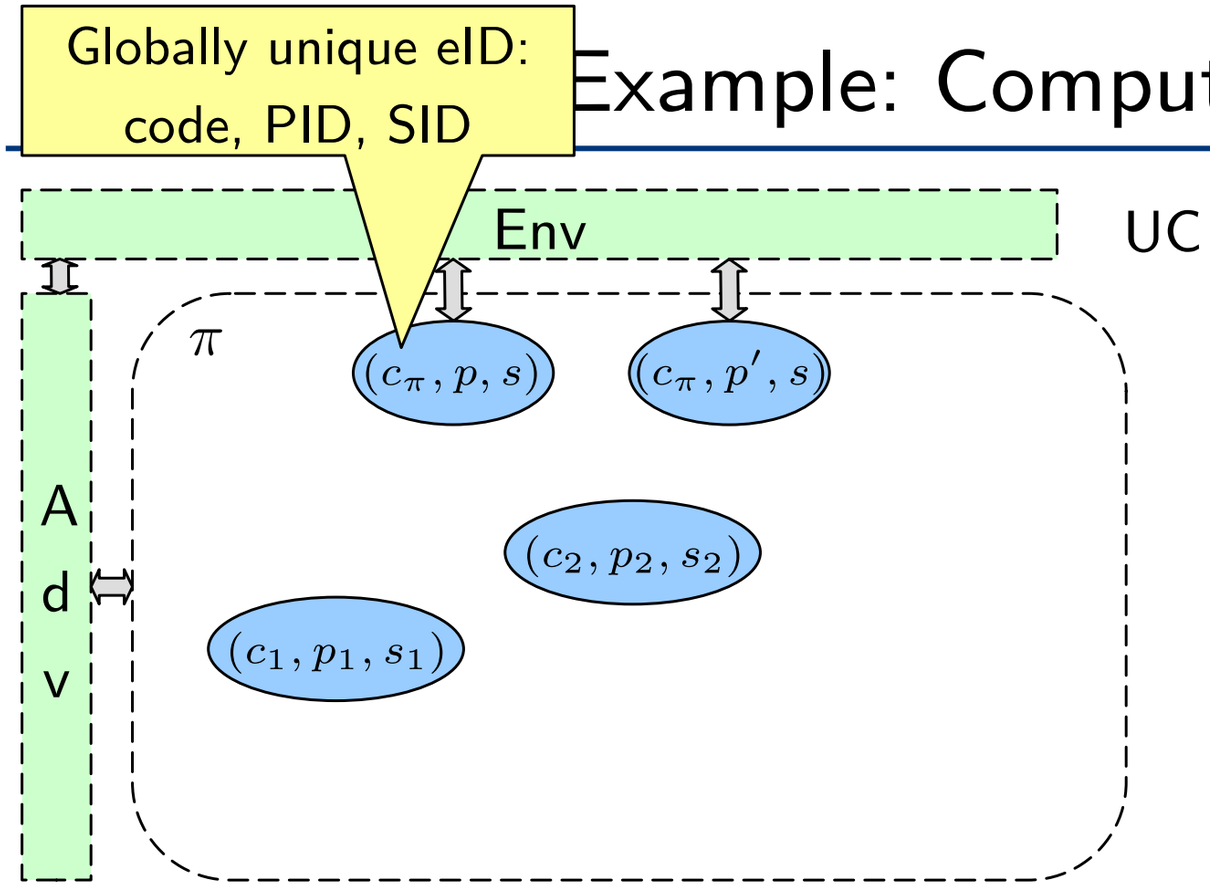

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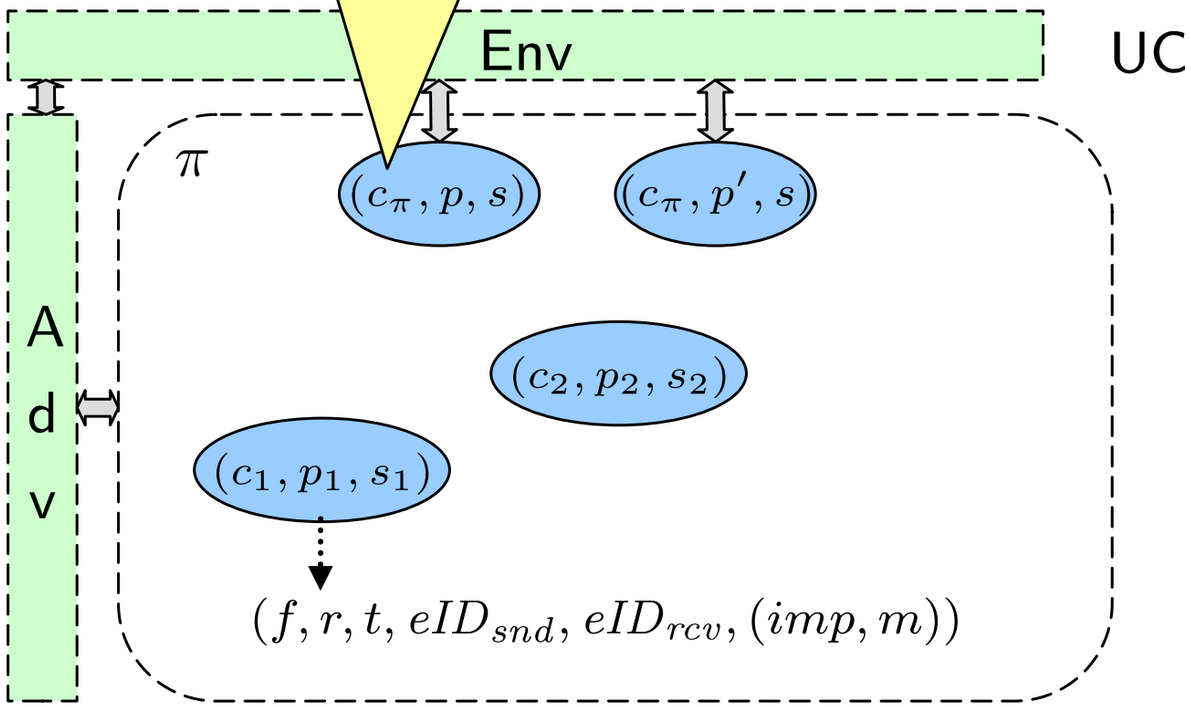

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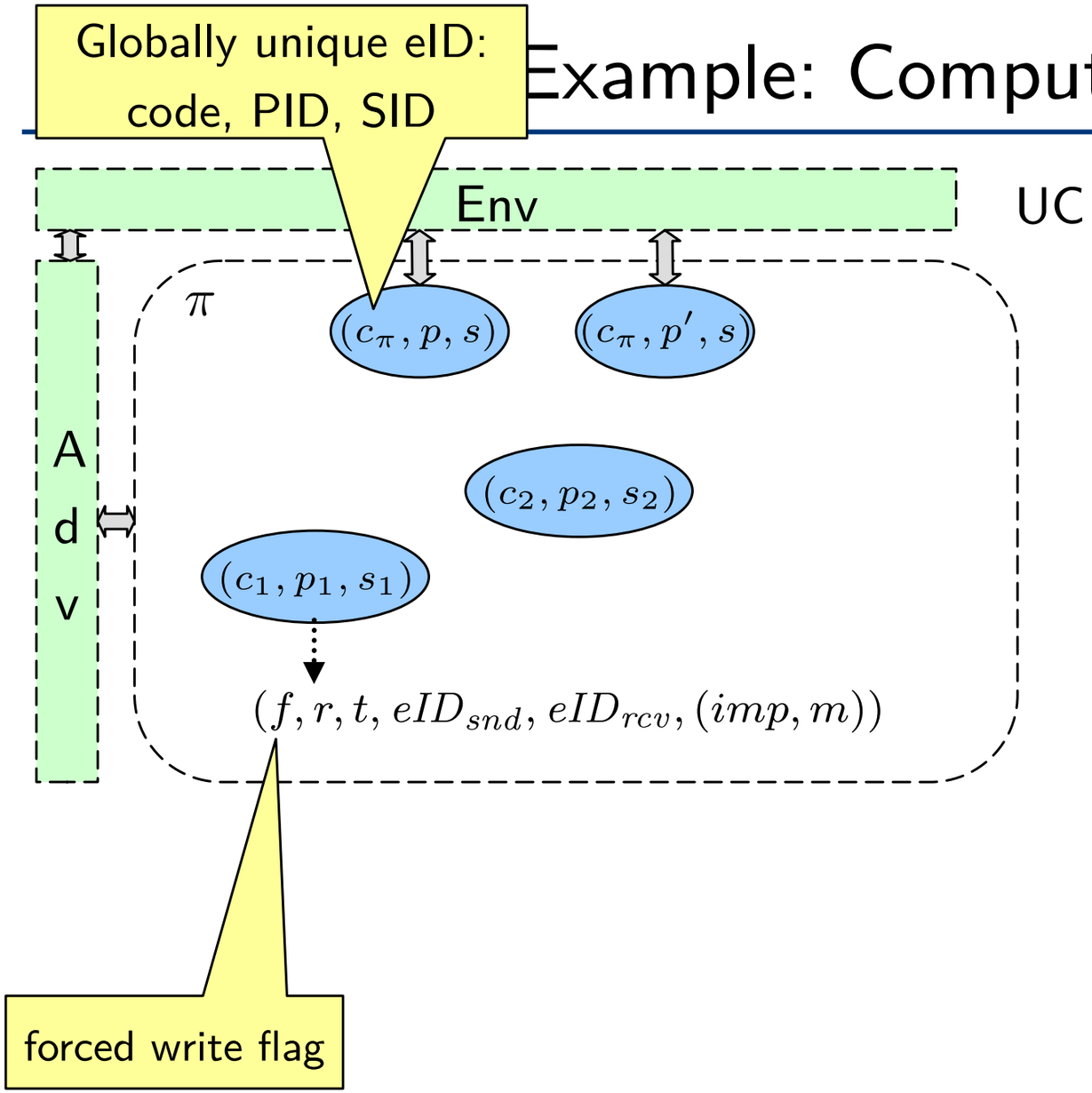

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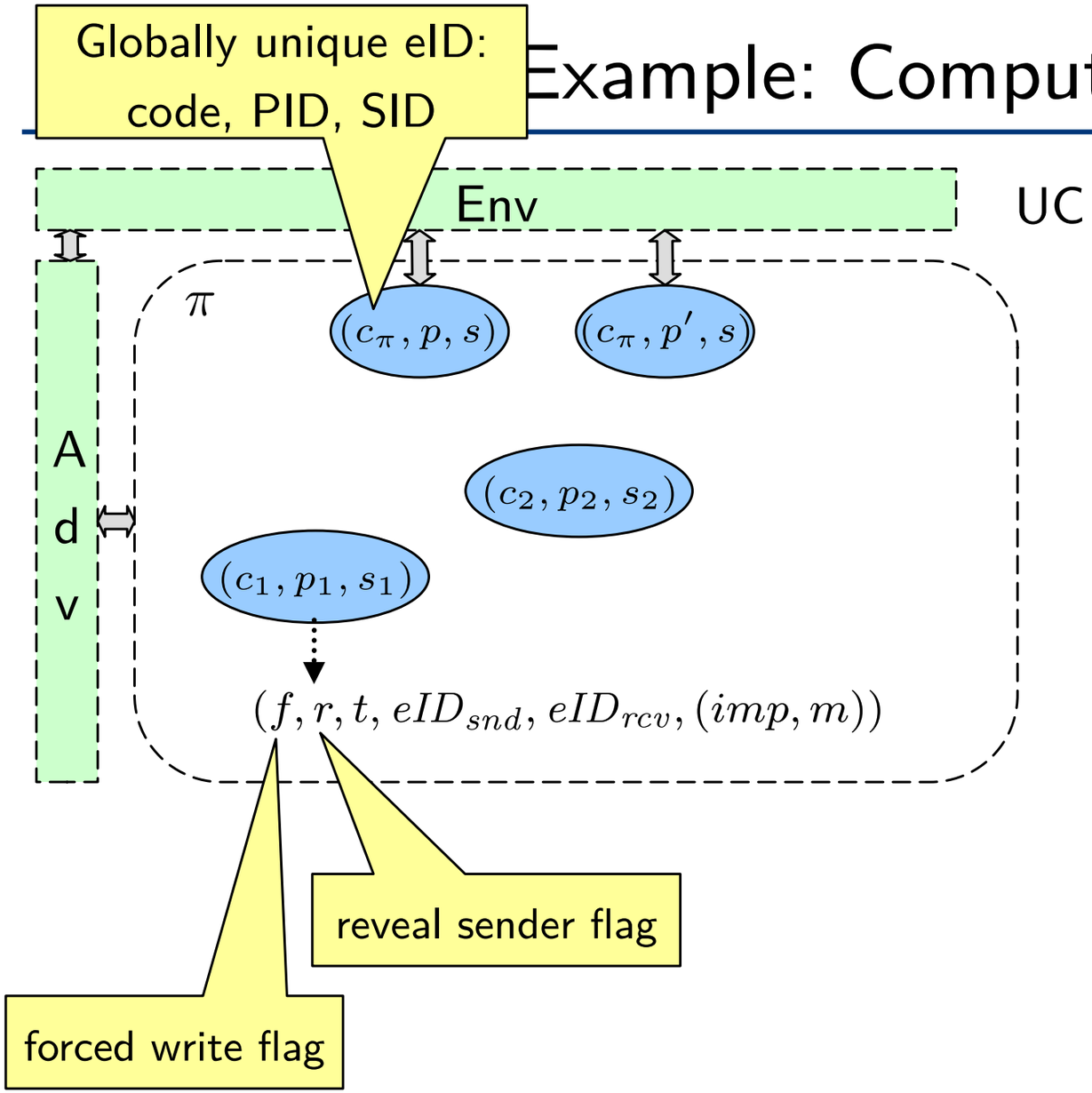

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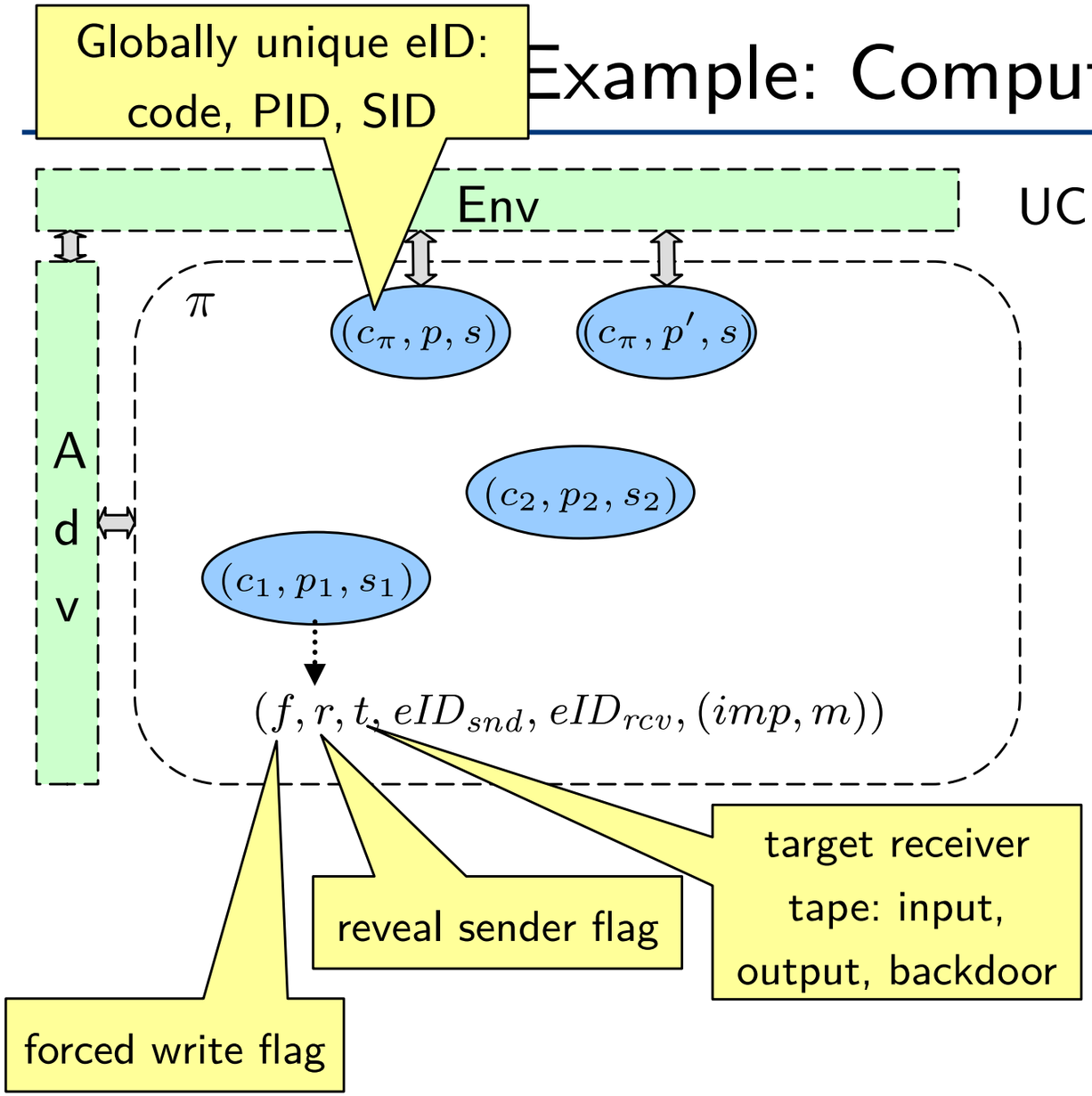

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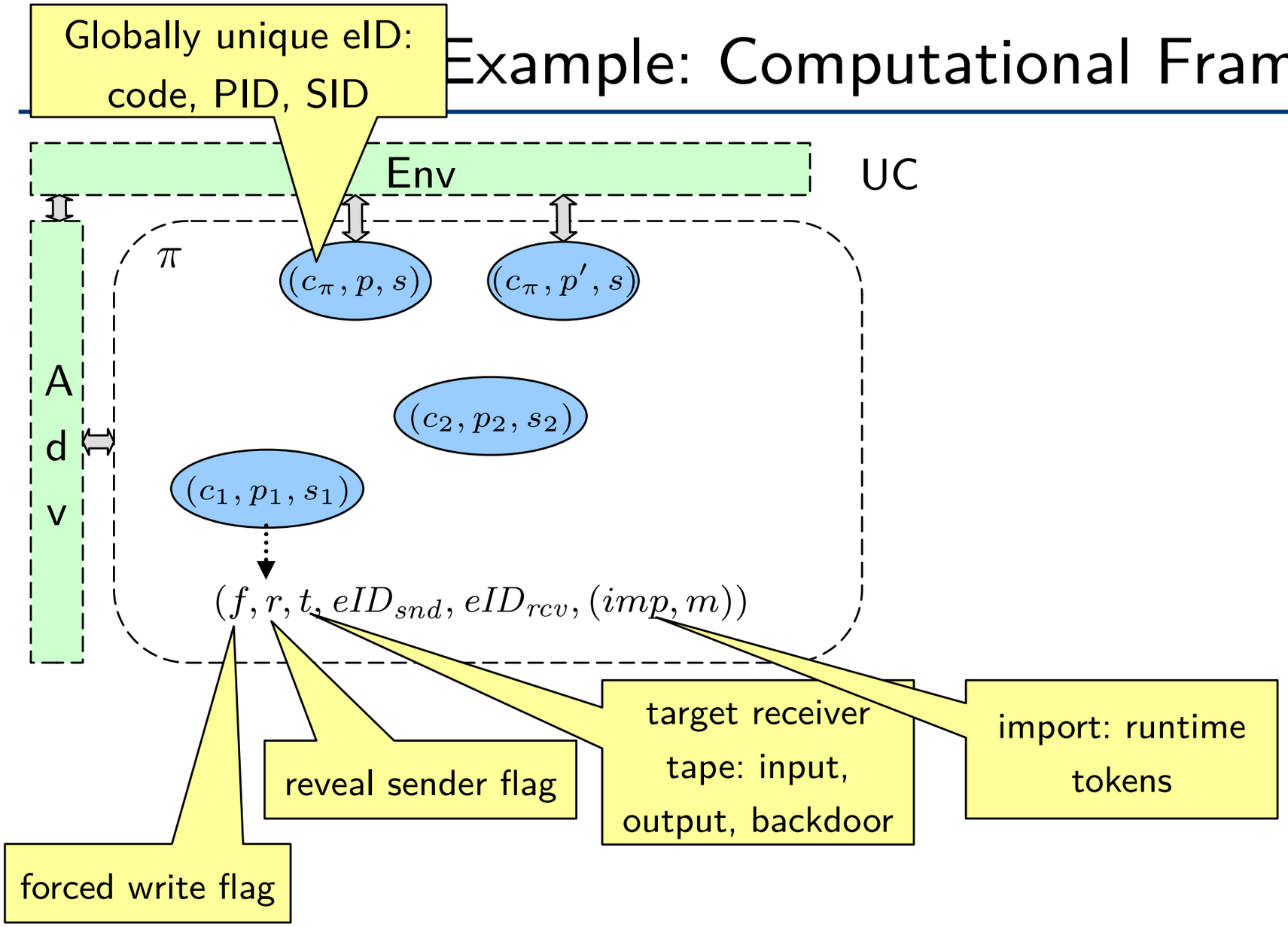

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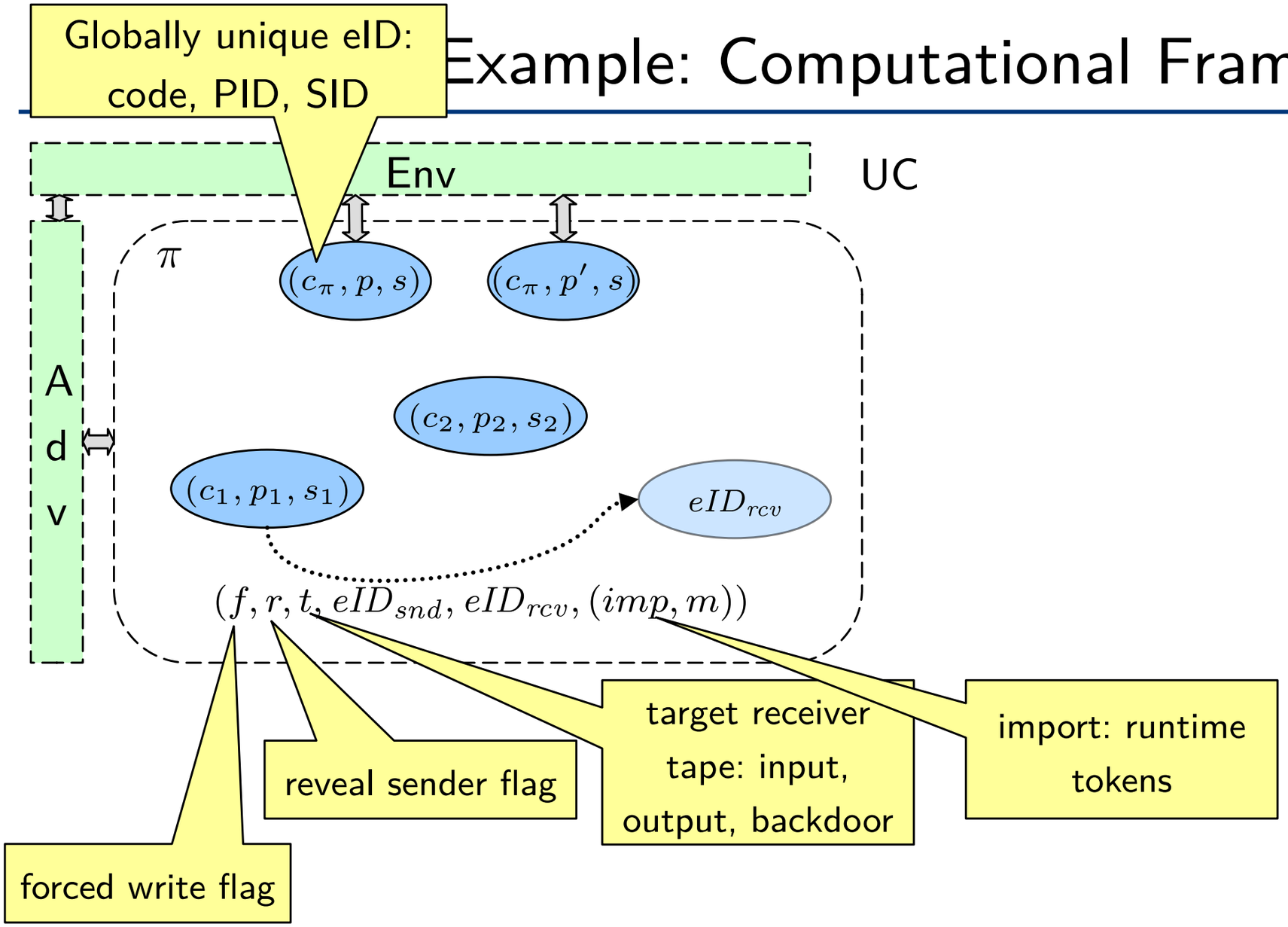

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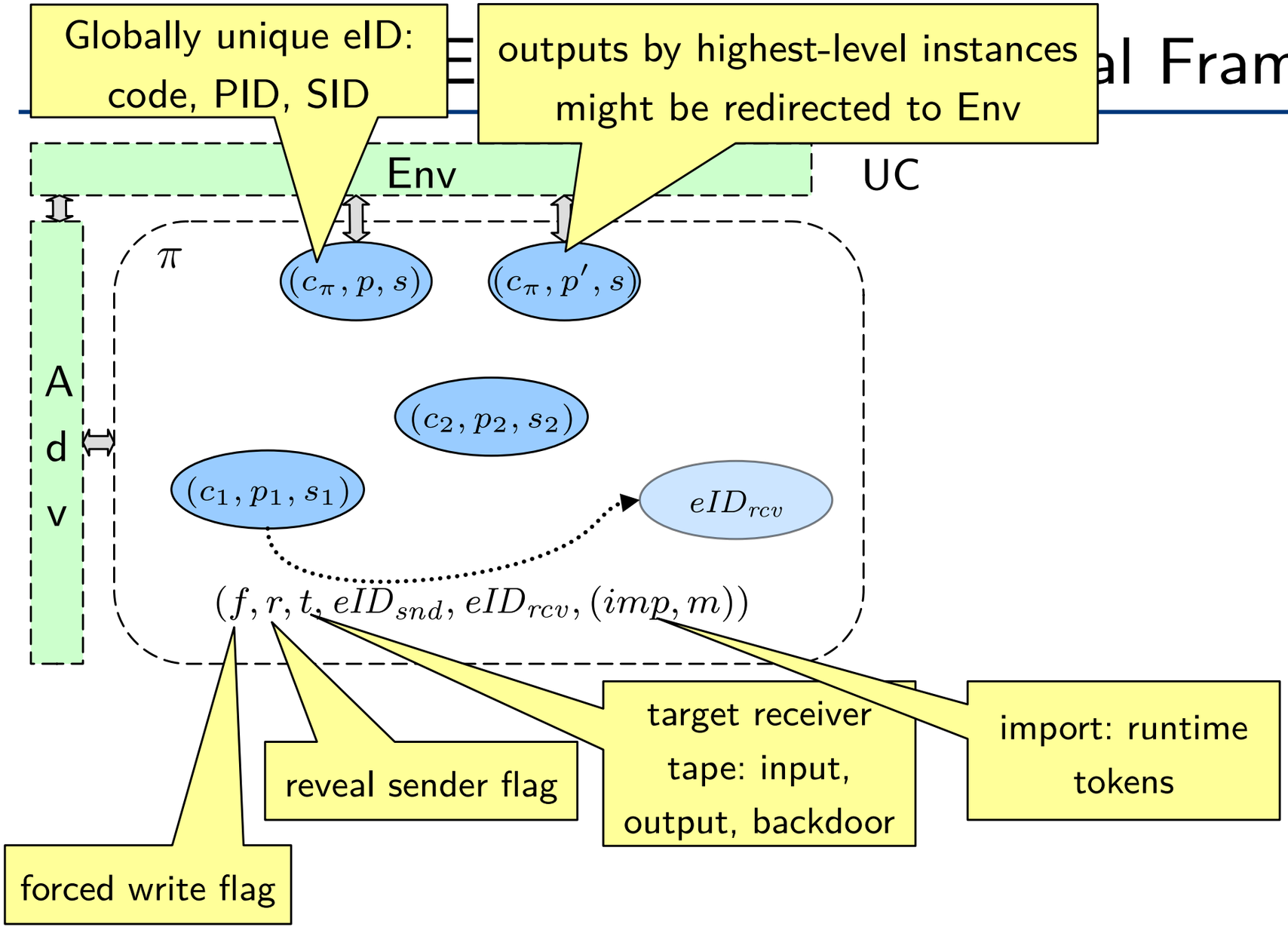

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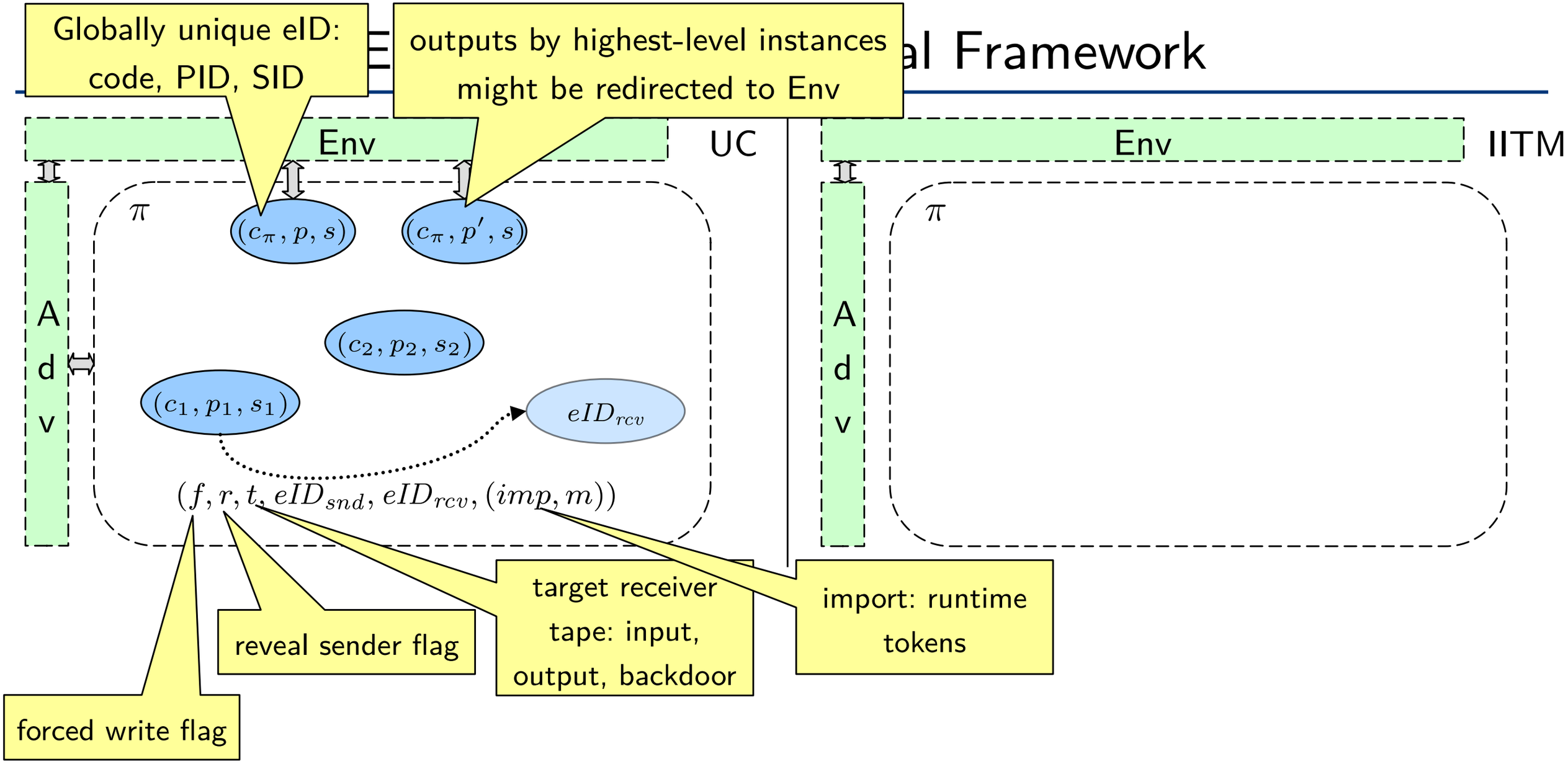

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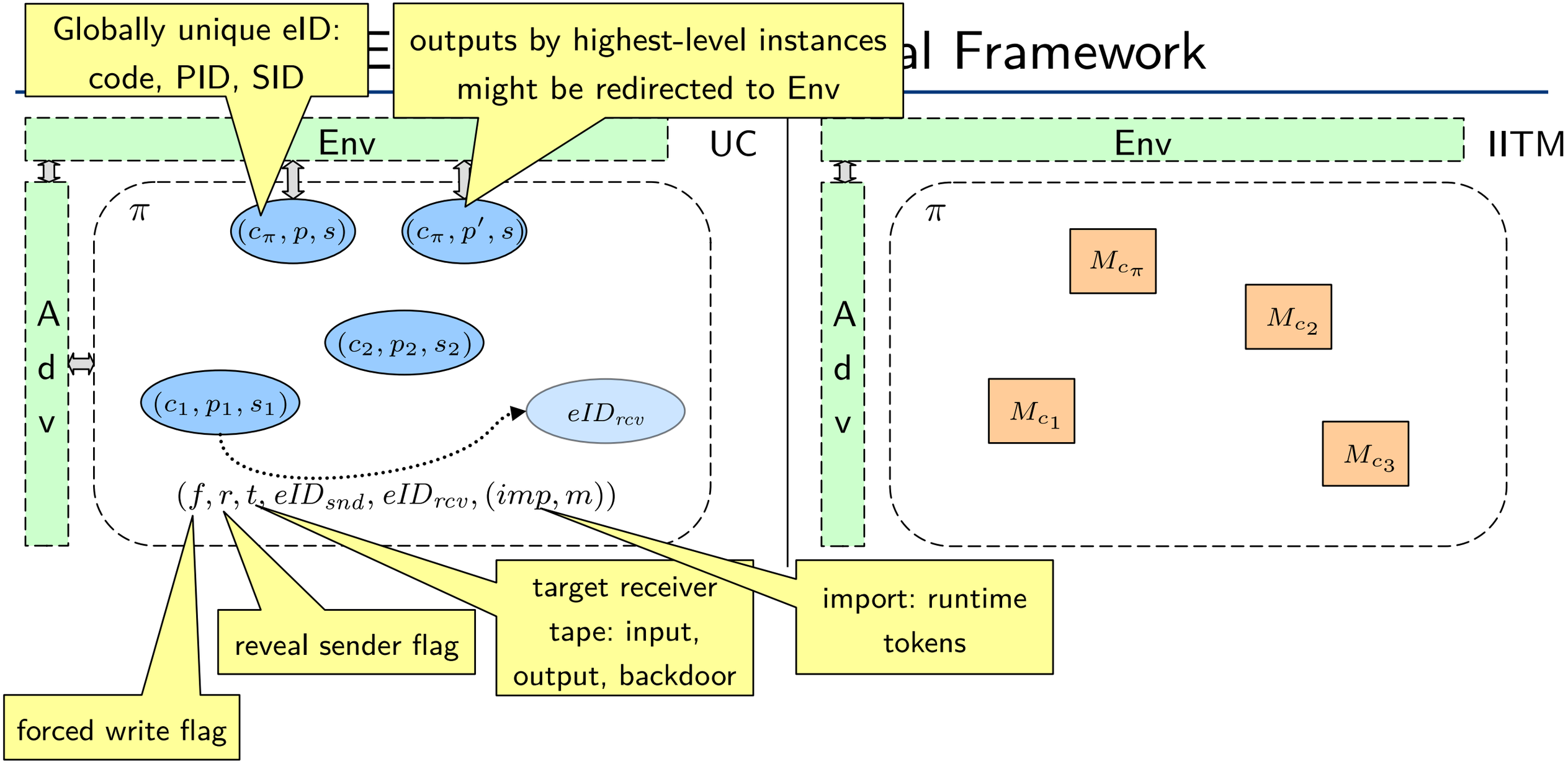

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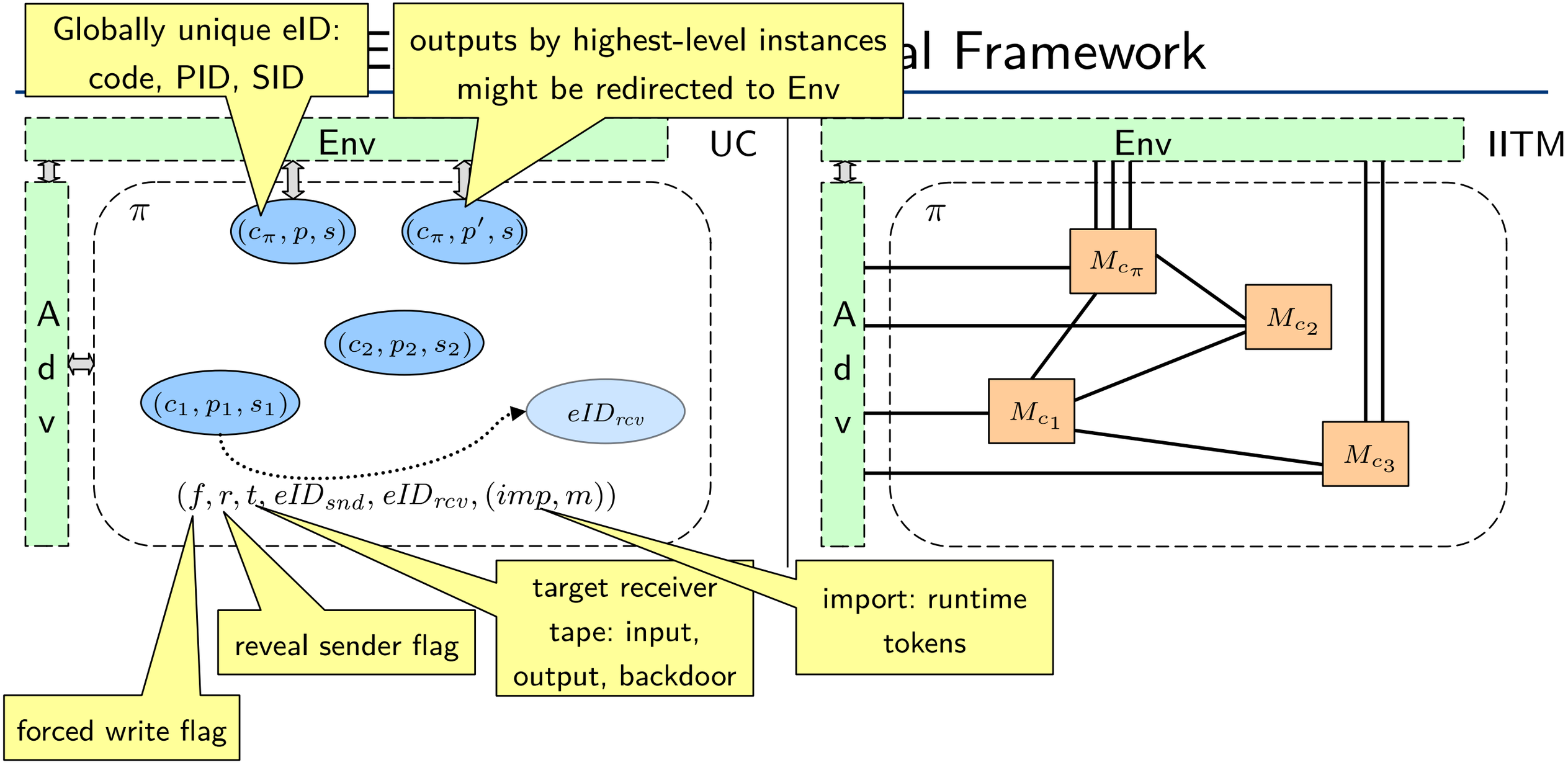

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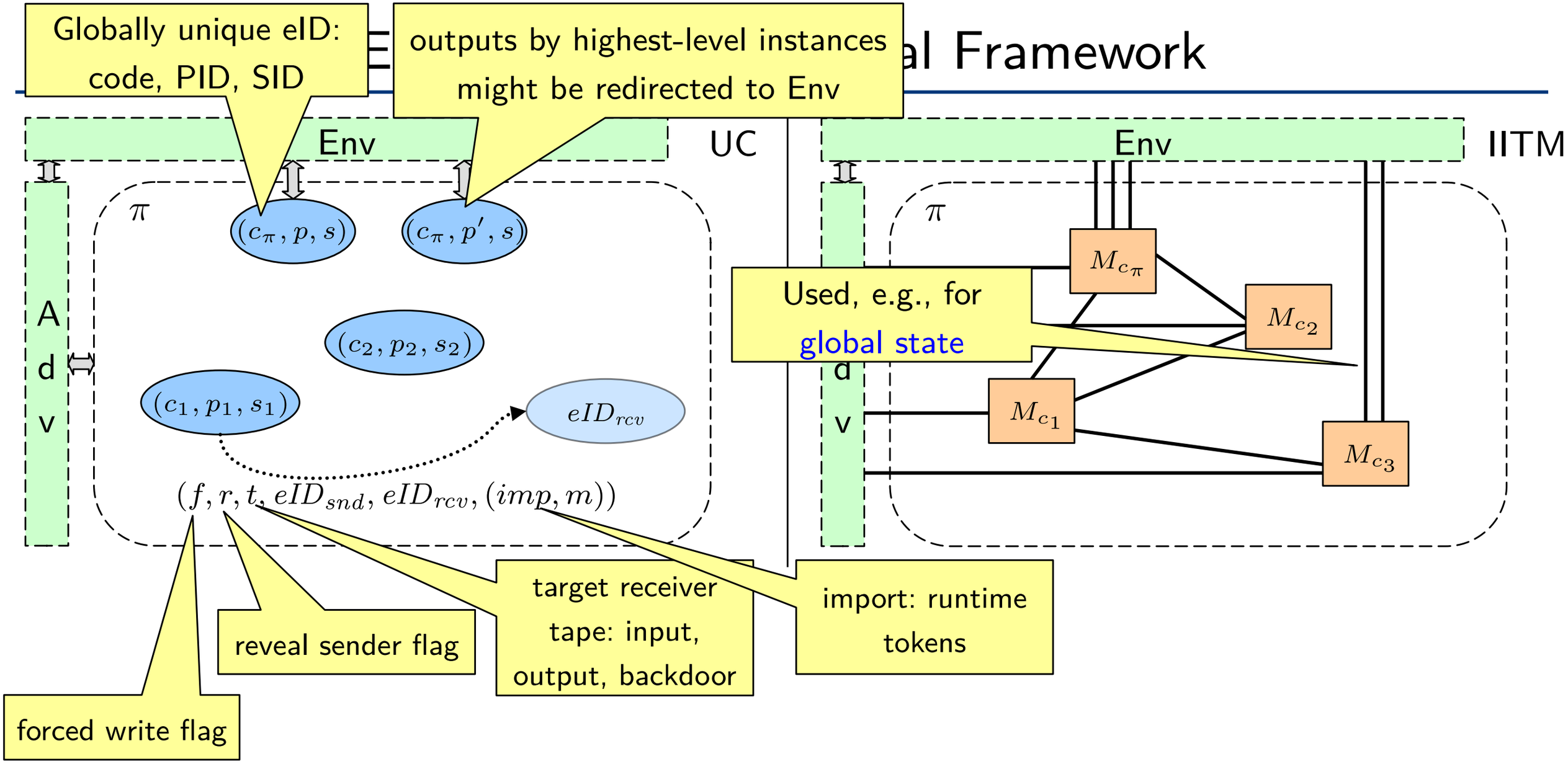

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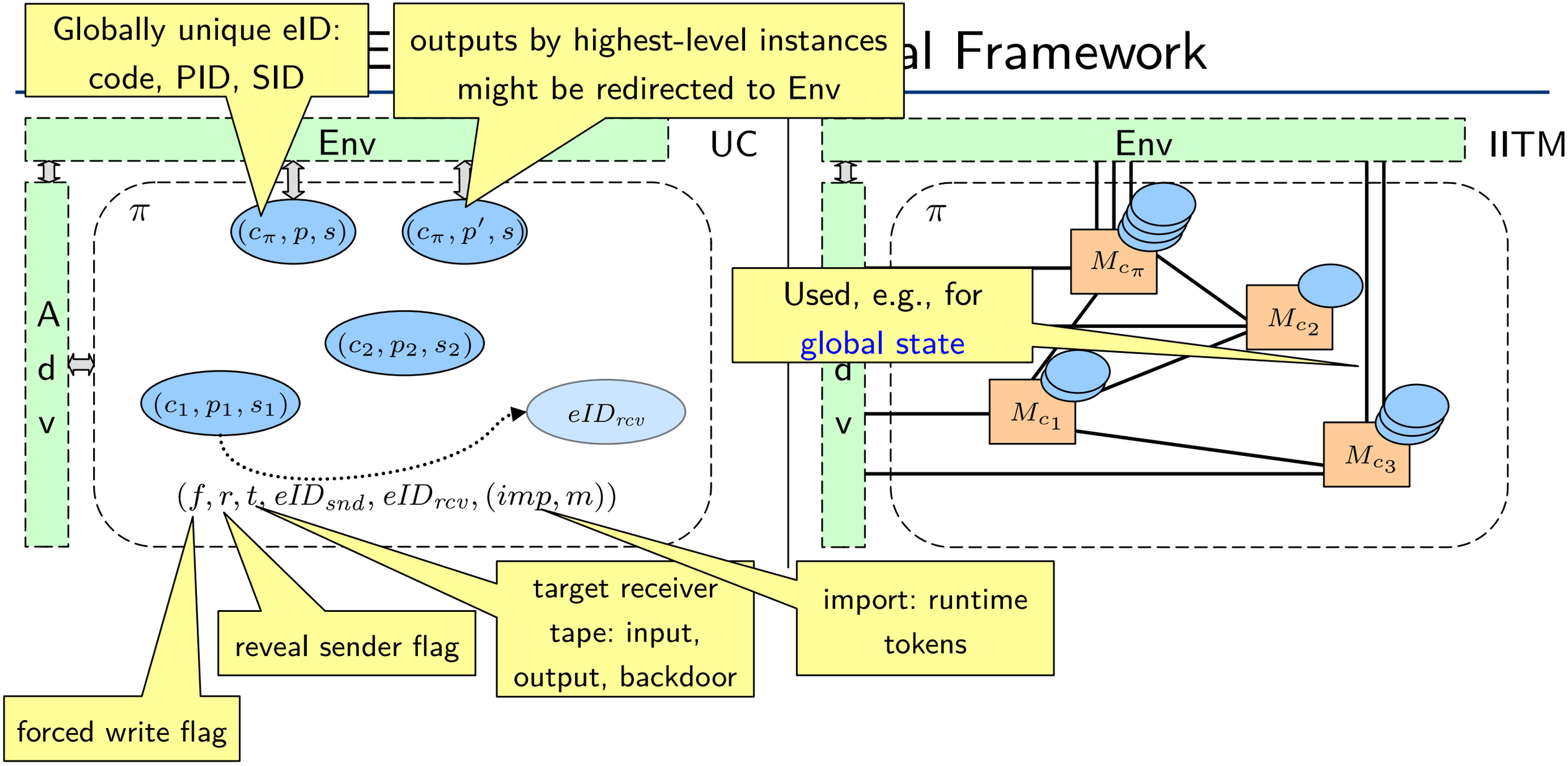

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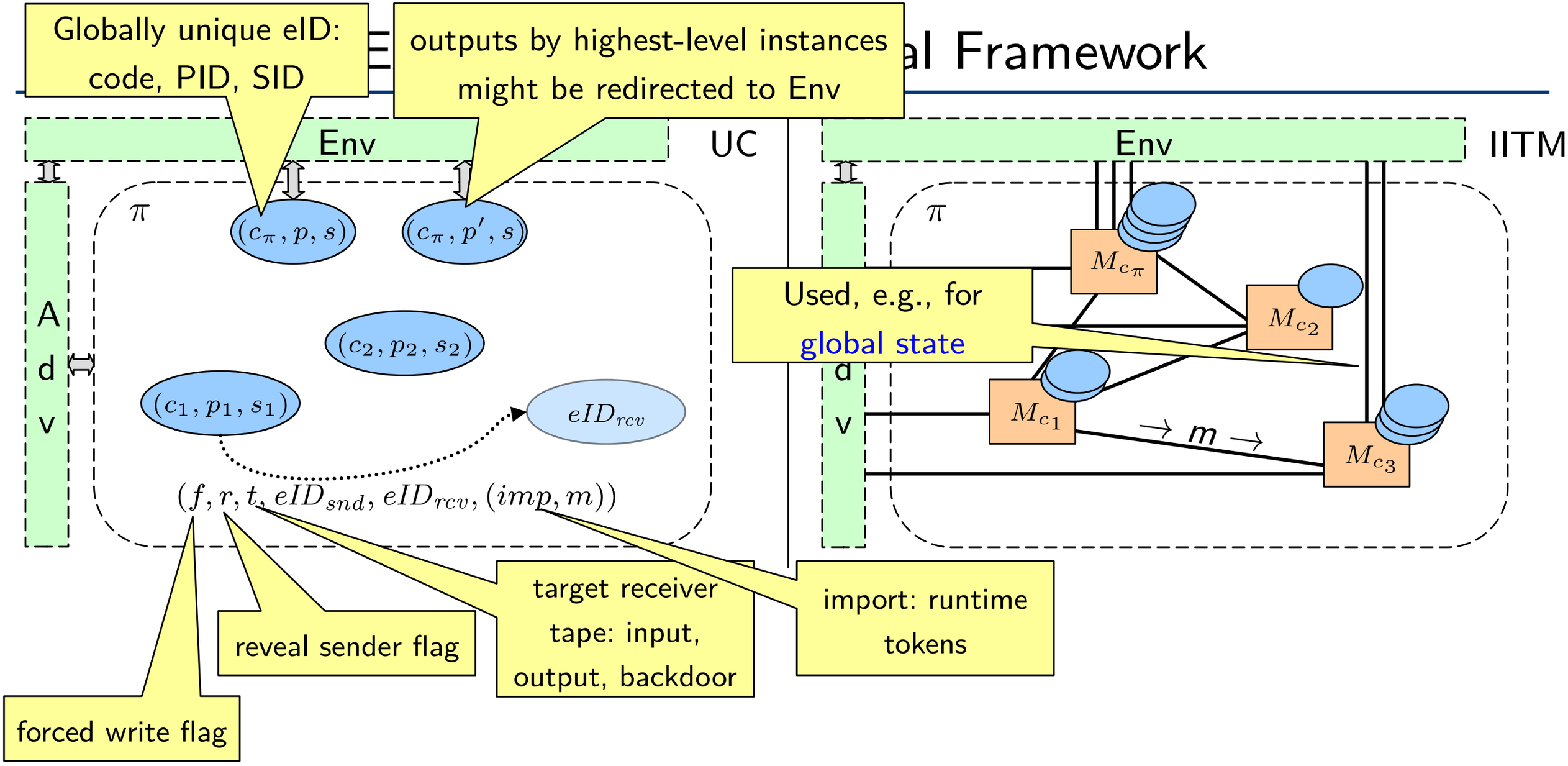

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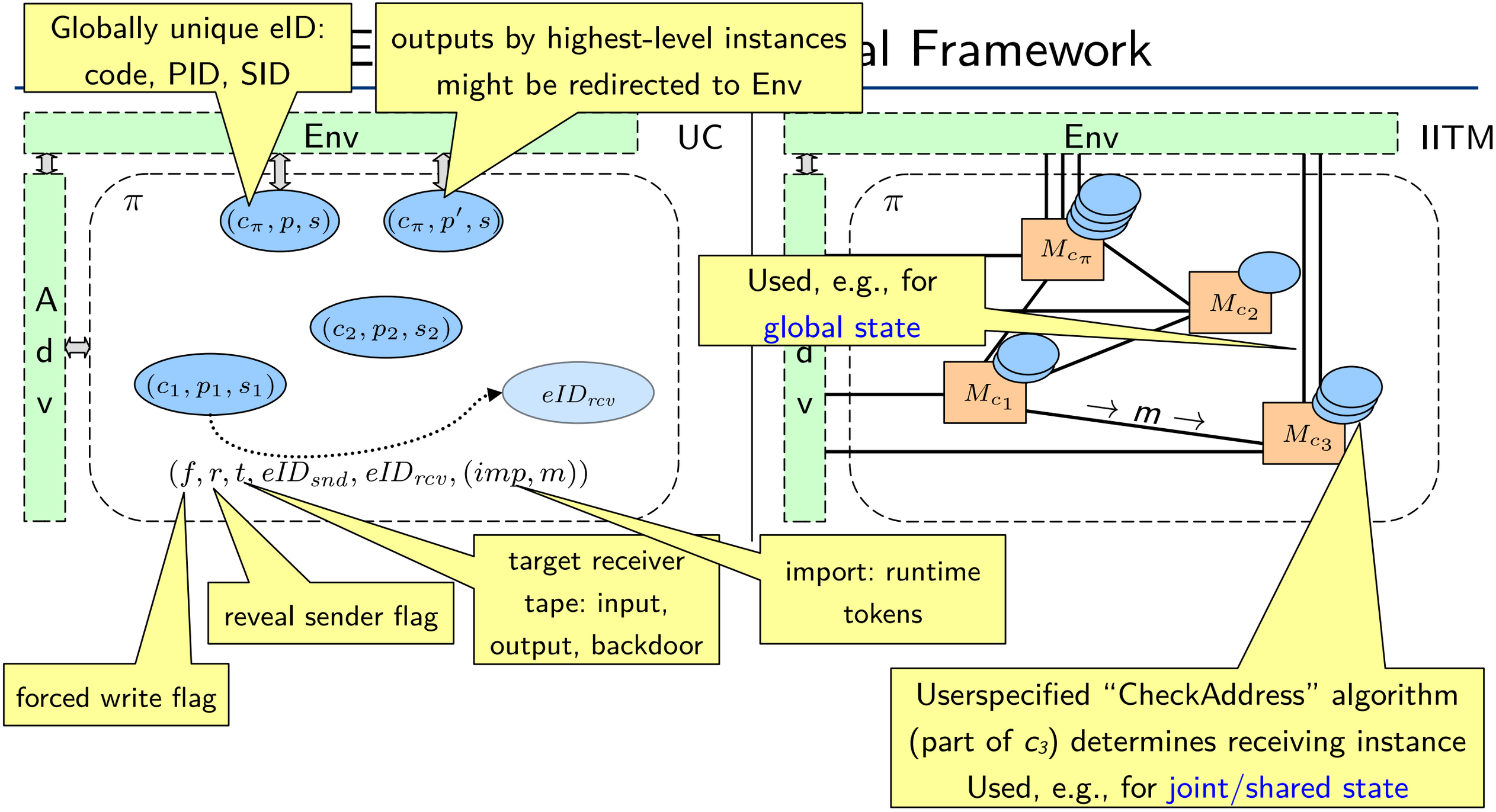

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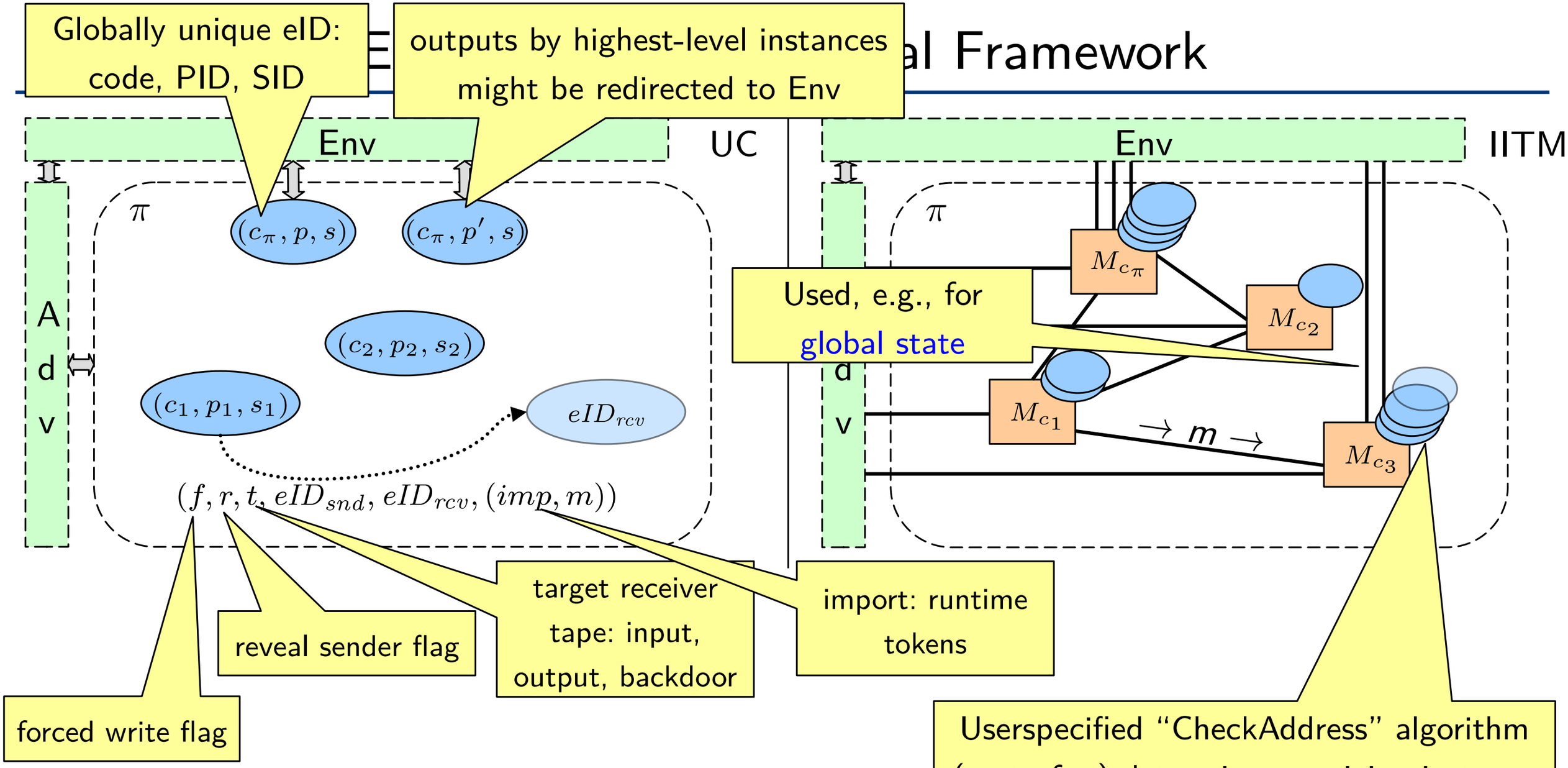
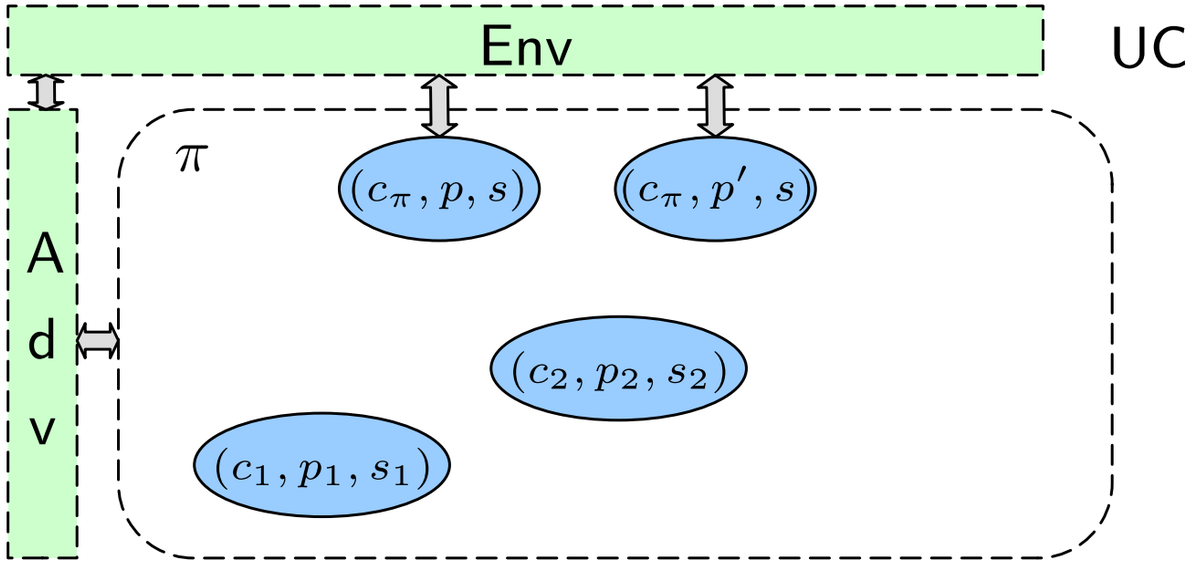


Example: Polynomial Runtime Notion



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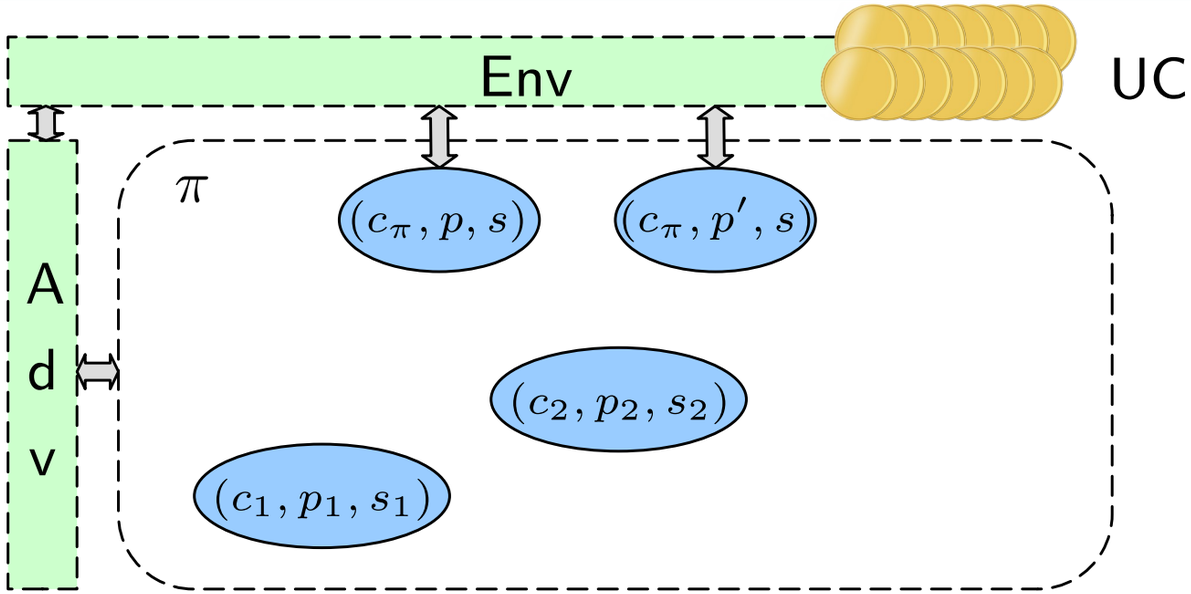

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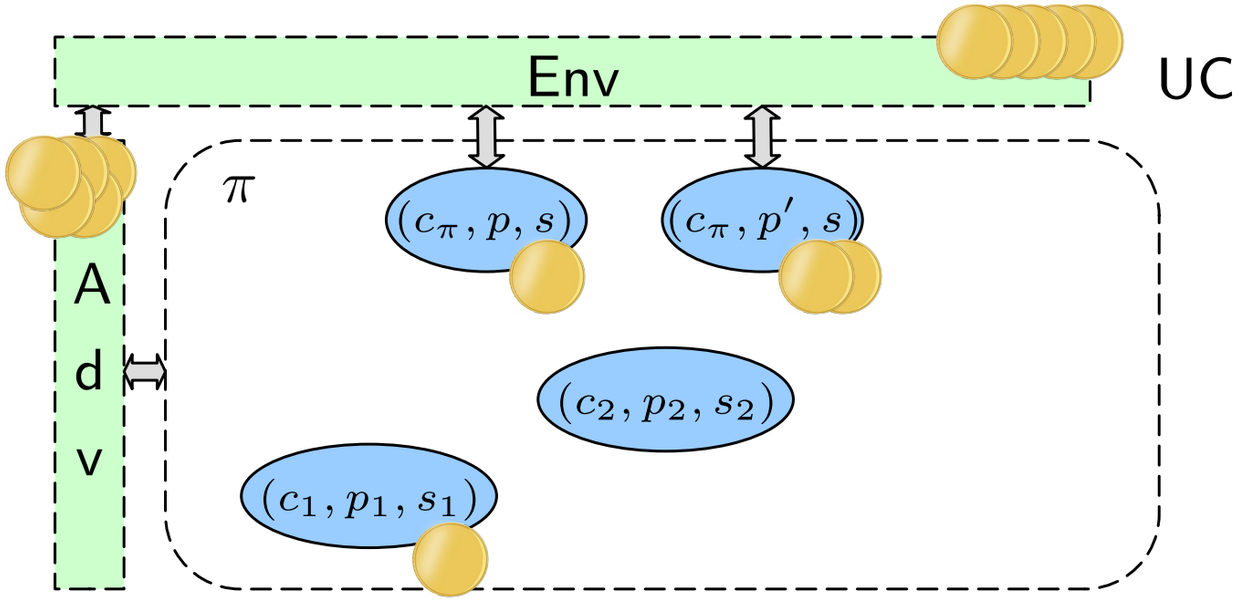

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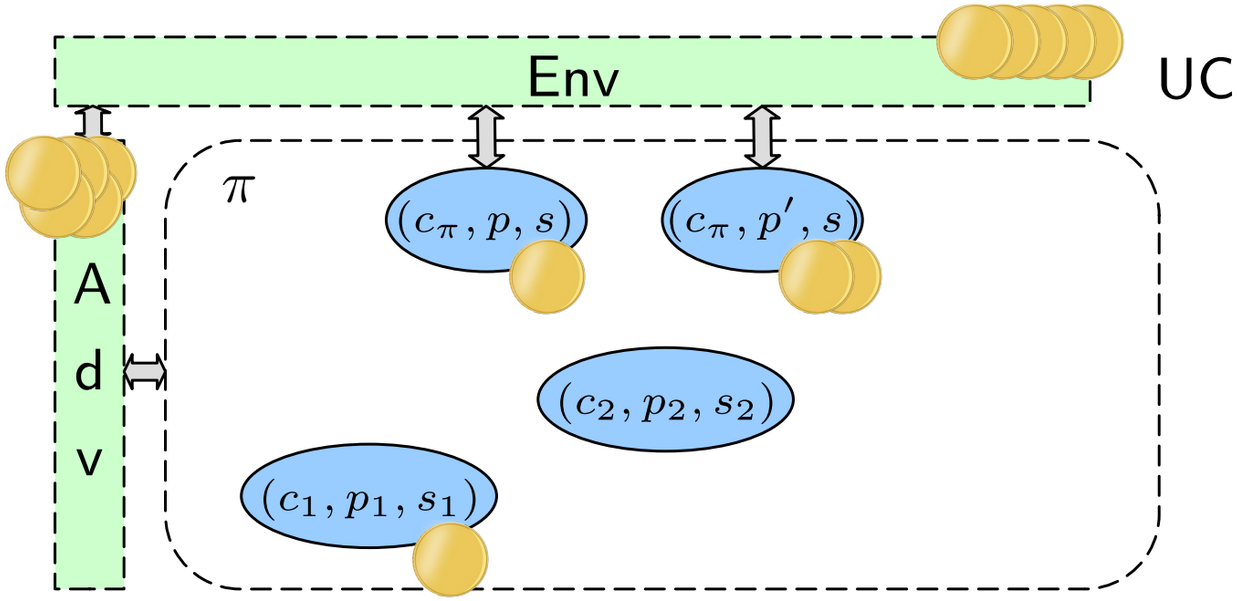

- All instances must be polytime in their currently held runtime tokens ("import")

  → Environment can determine runtime and force protocol/simulator to stop

  → Has to be taken into account in simulation

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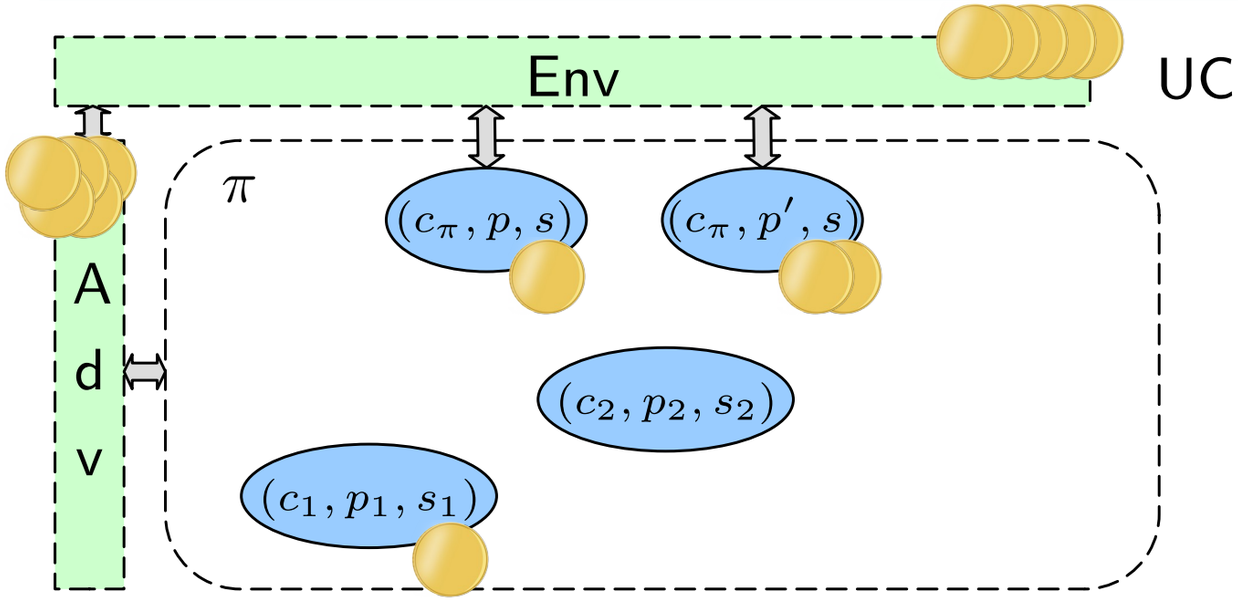

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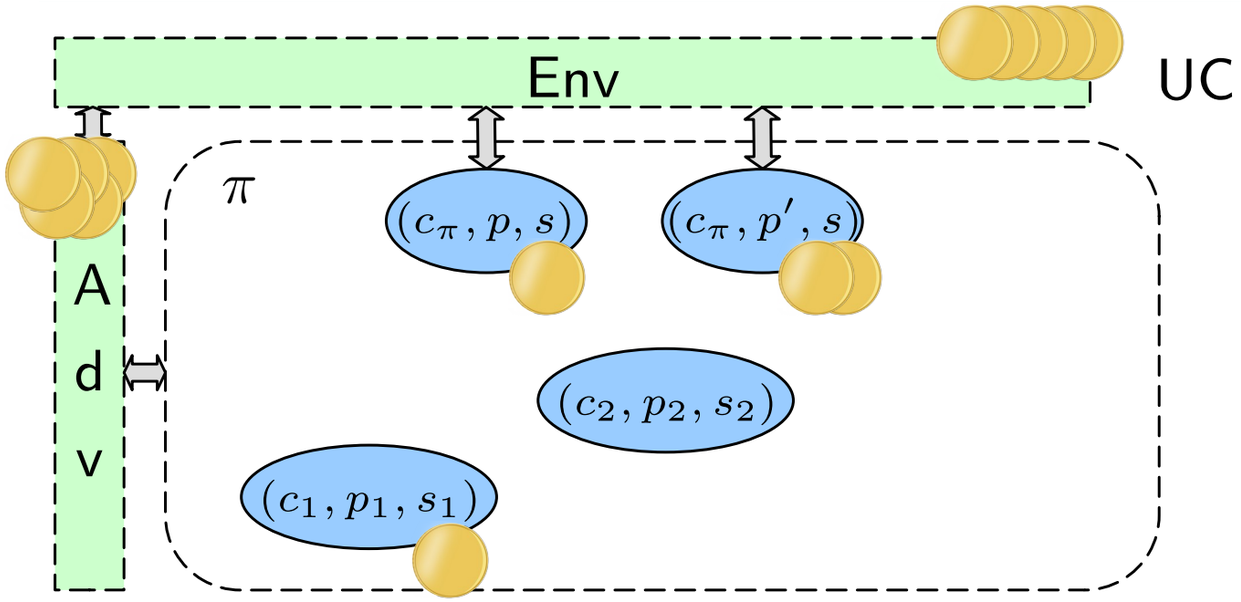

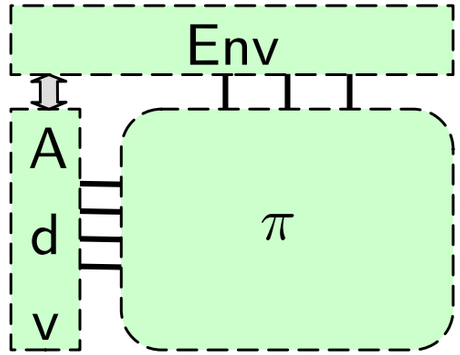

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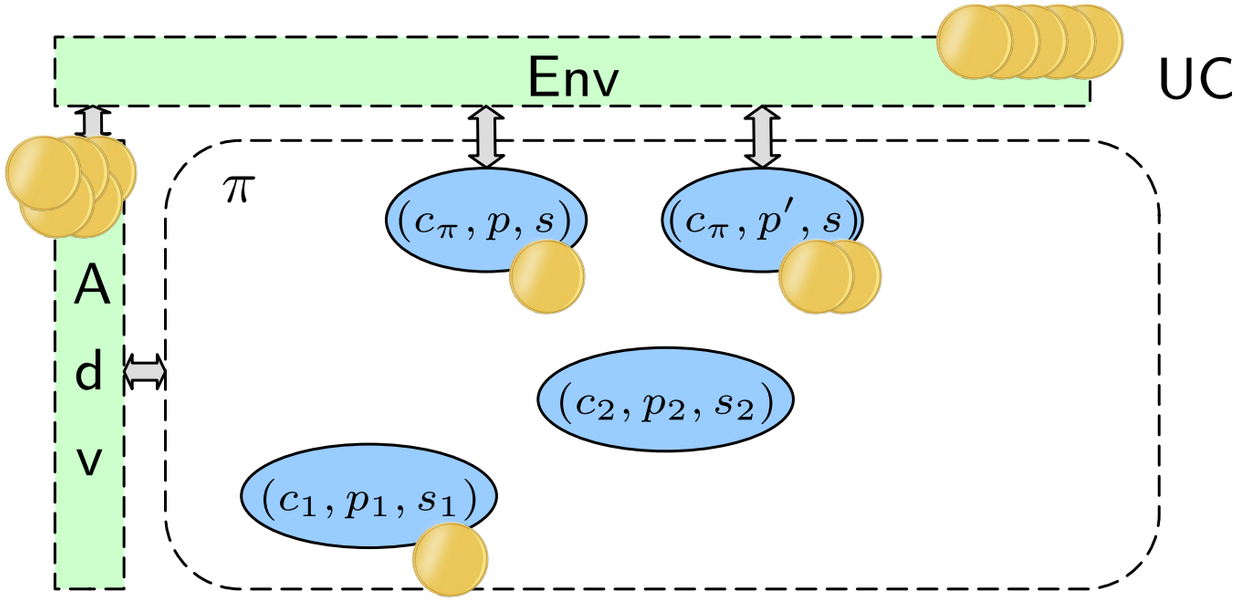

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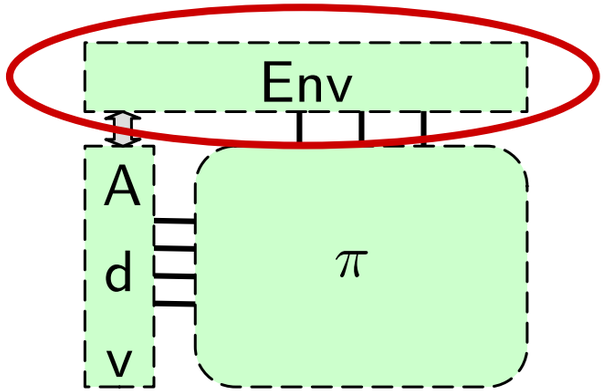

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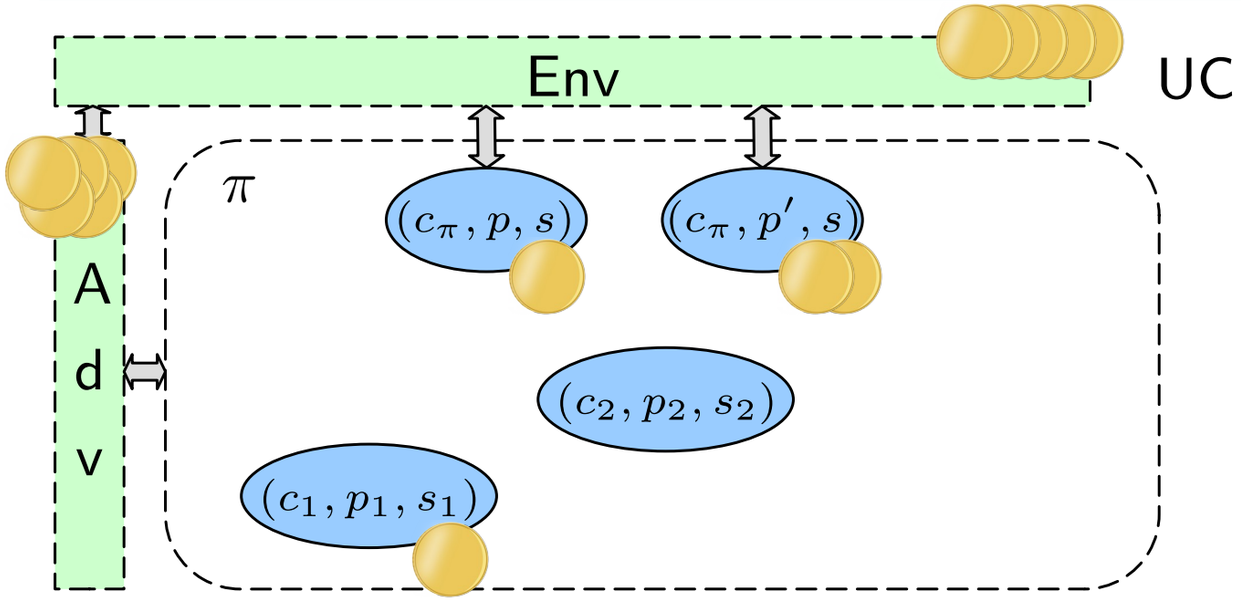

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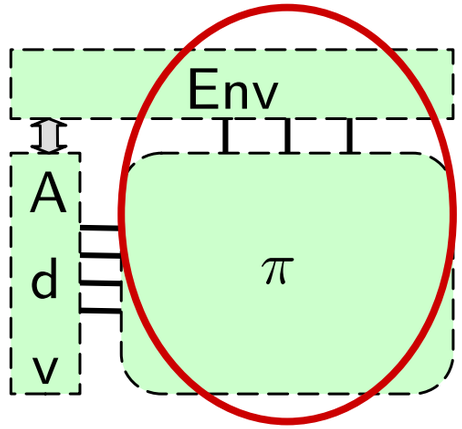

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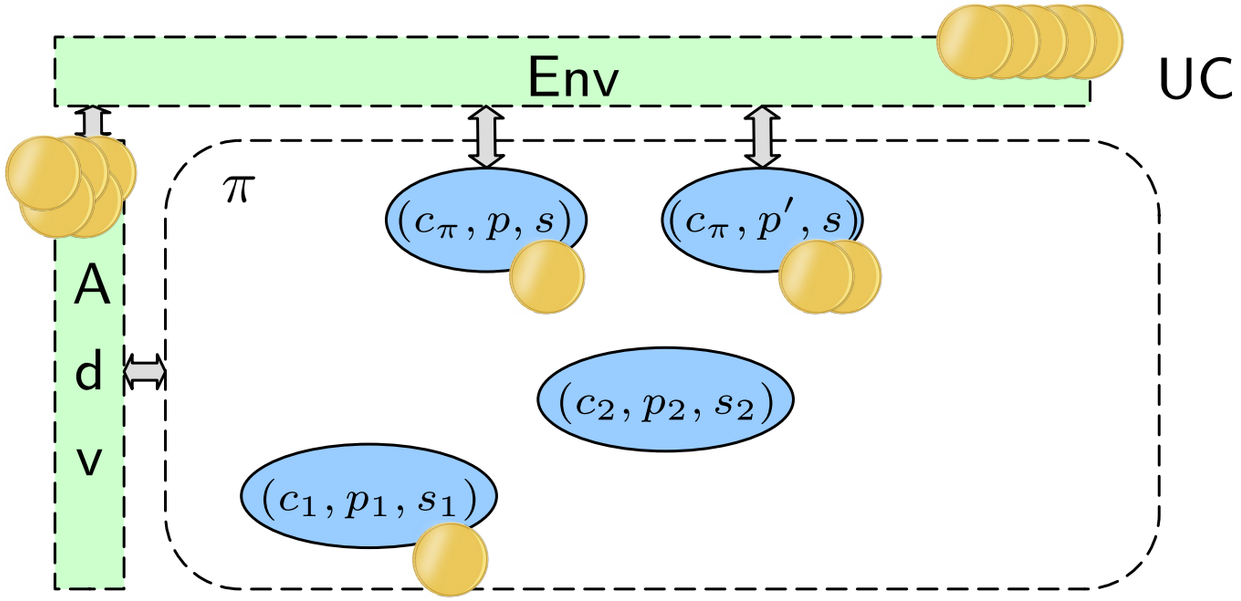

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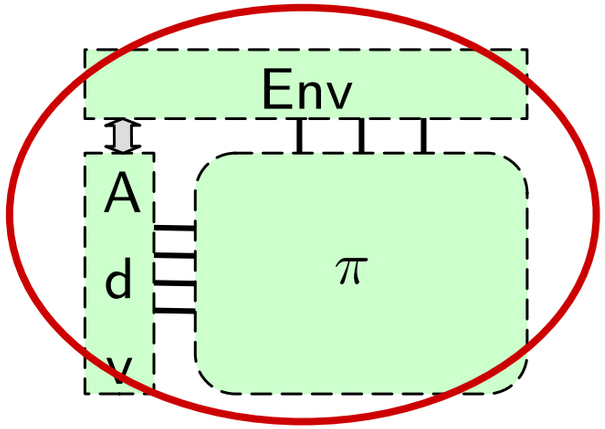

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Example: Composition

UC Theorem:

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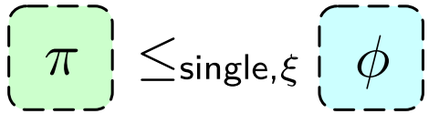

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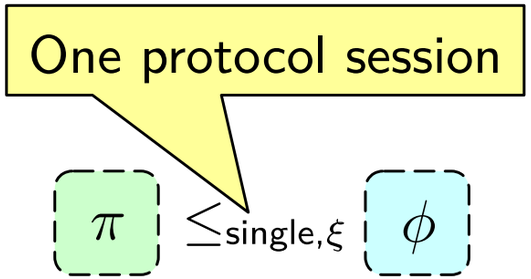

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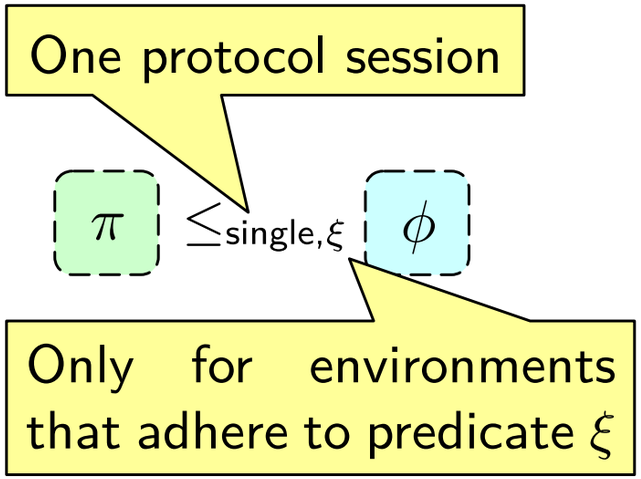

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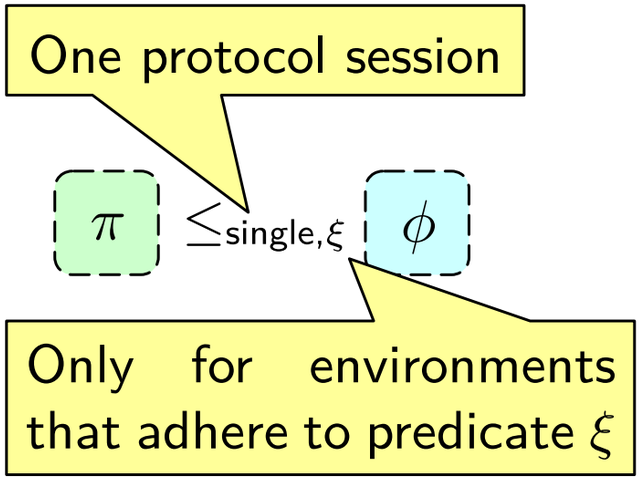

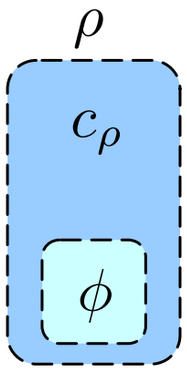

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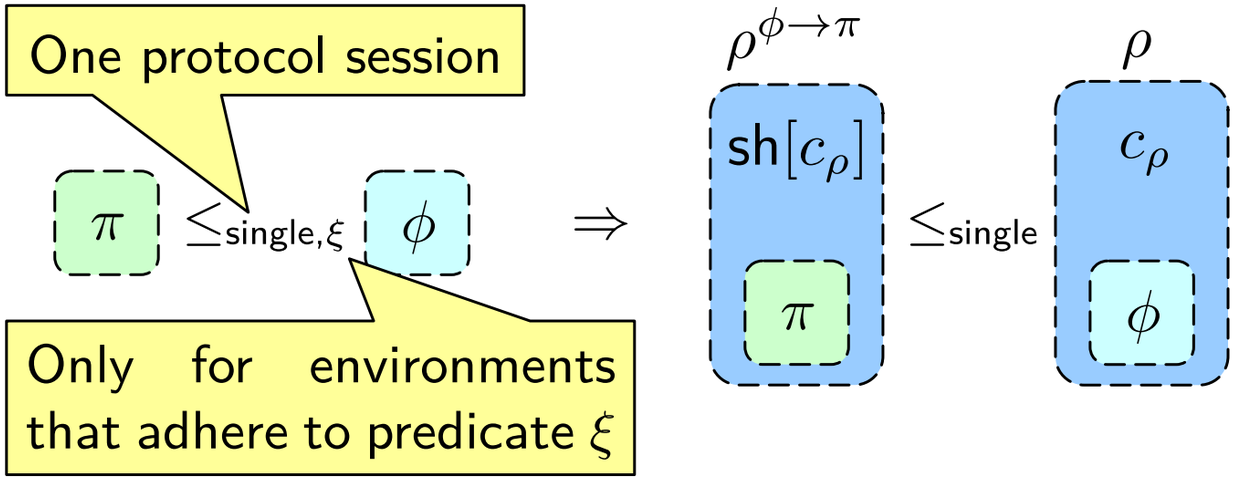

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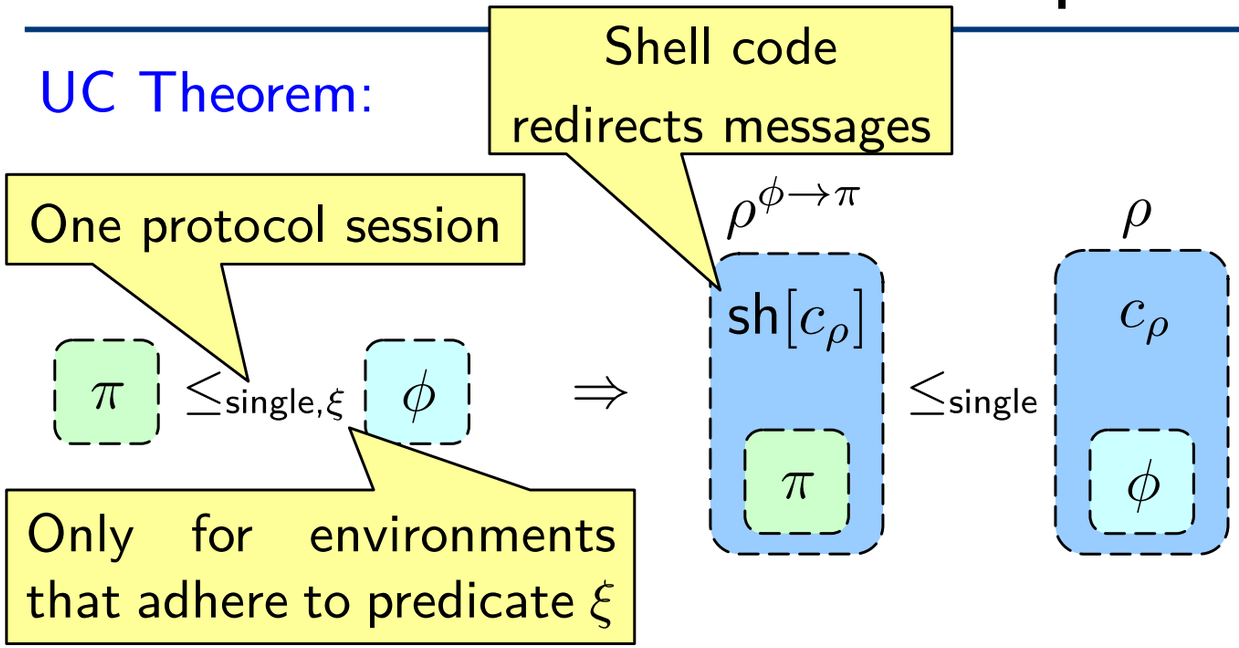

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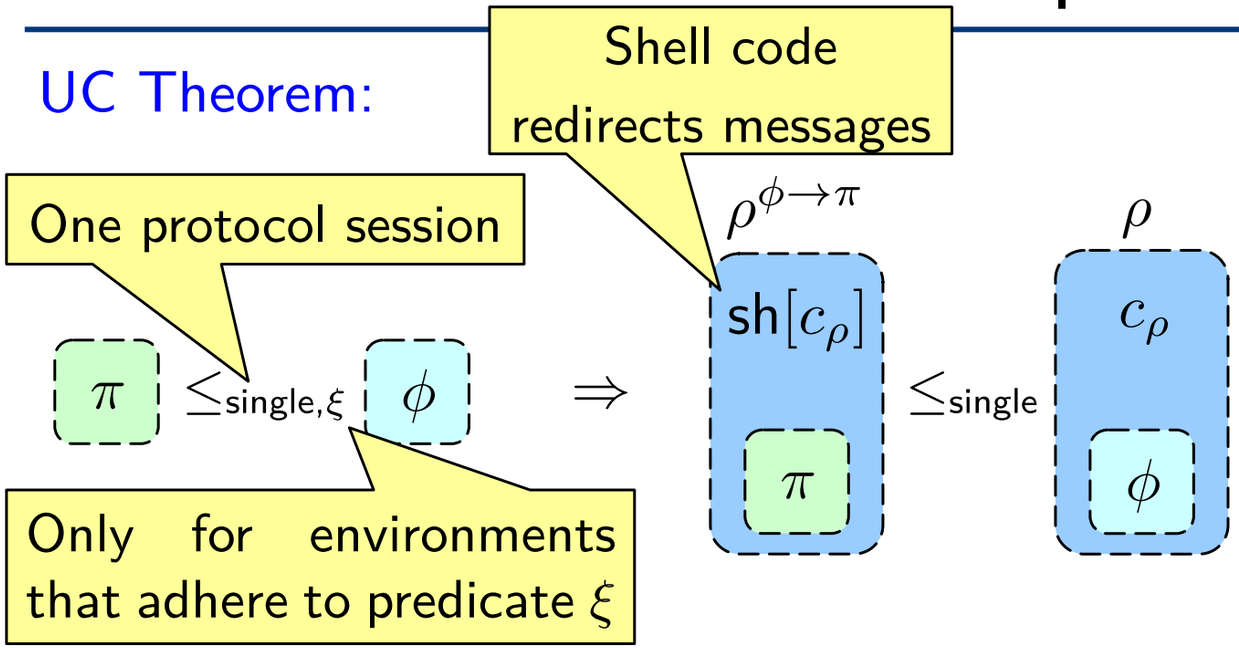

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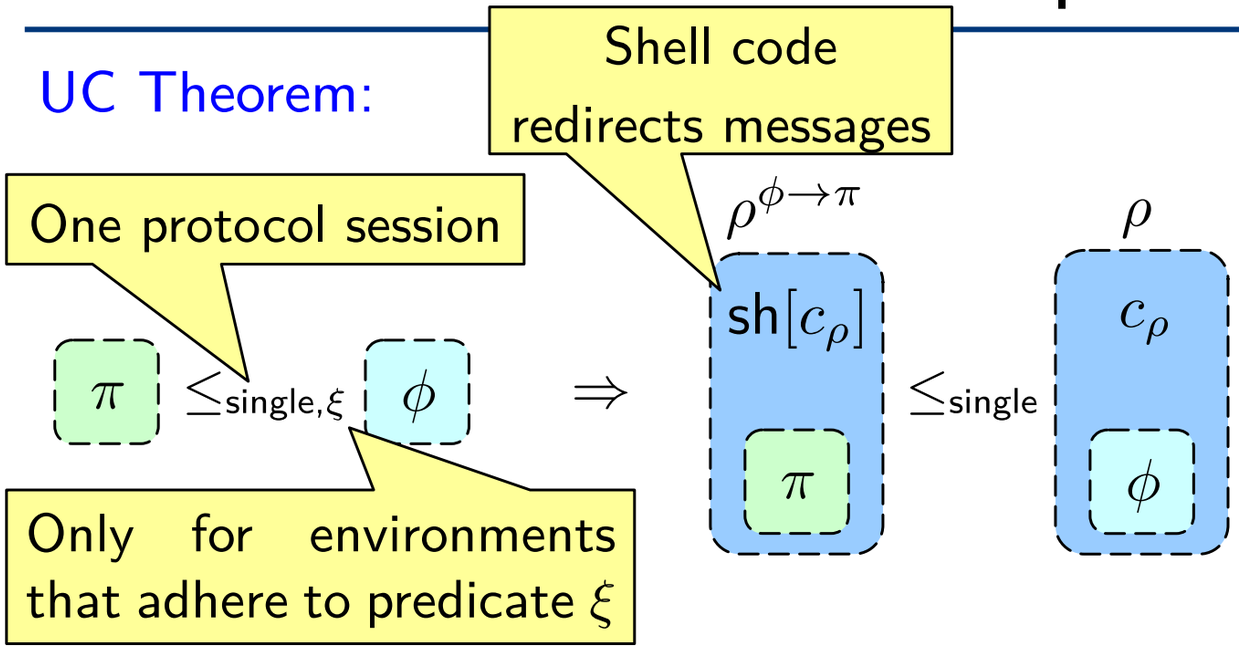

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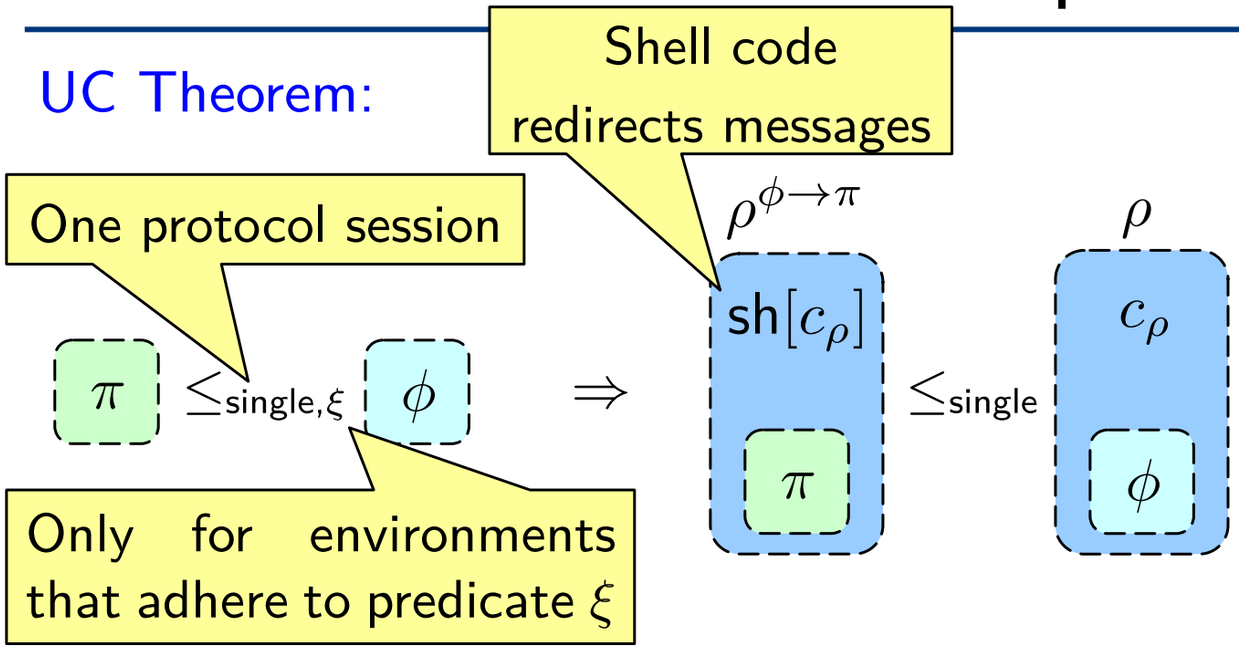

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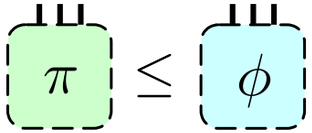

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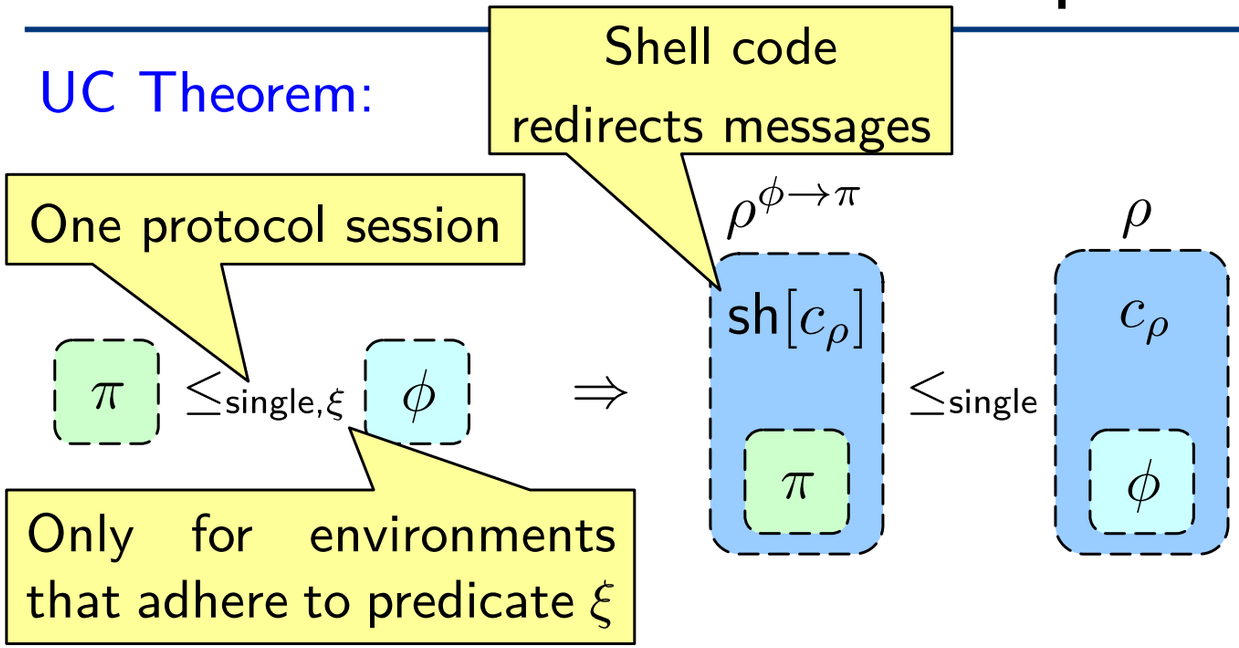

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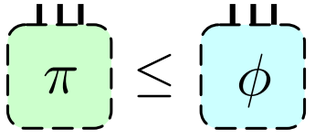

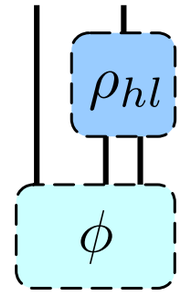

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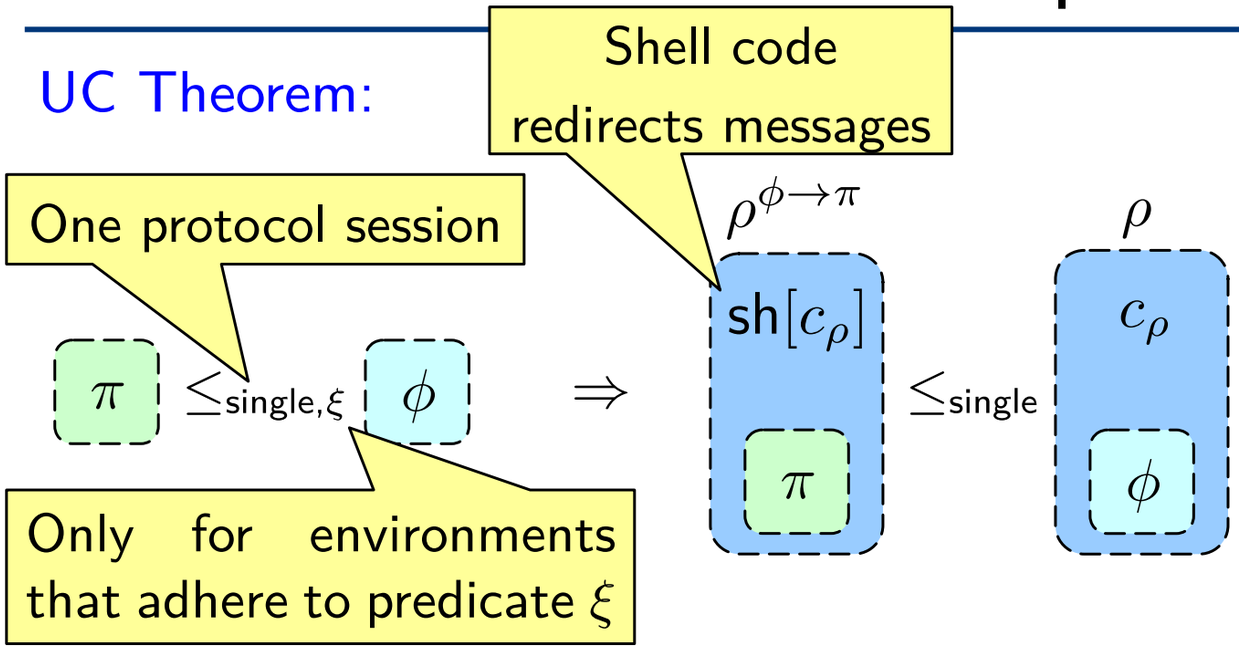

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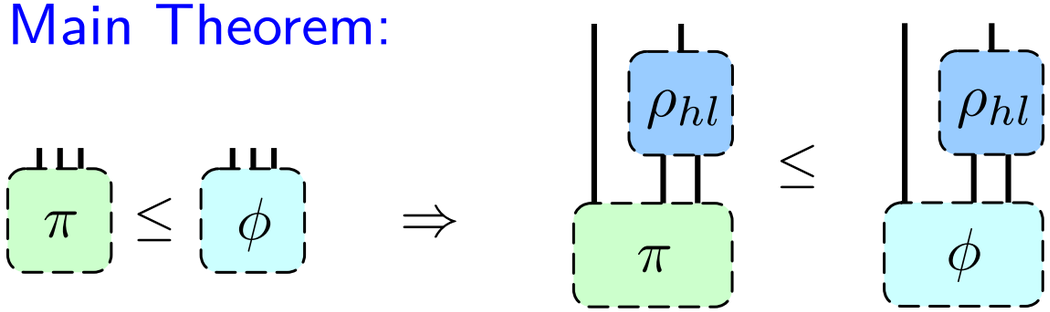

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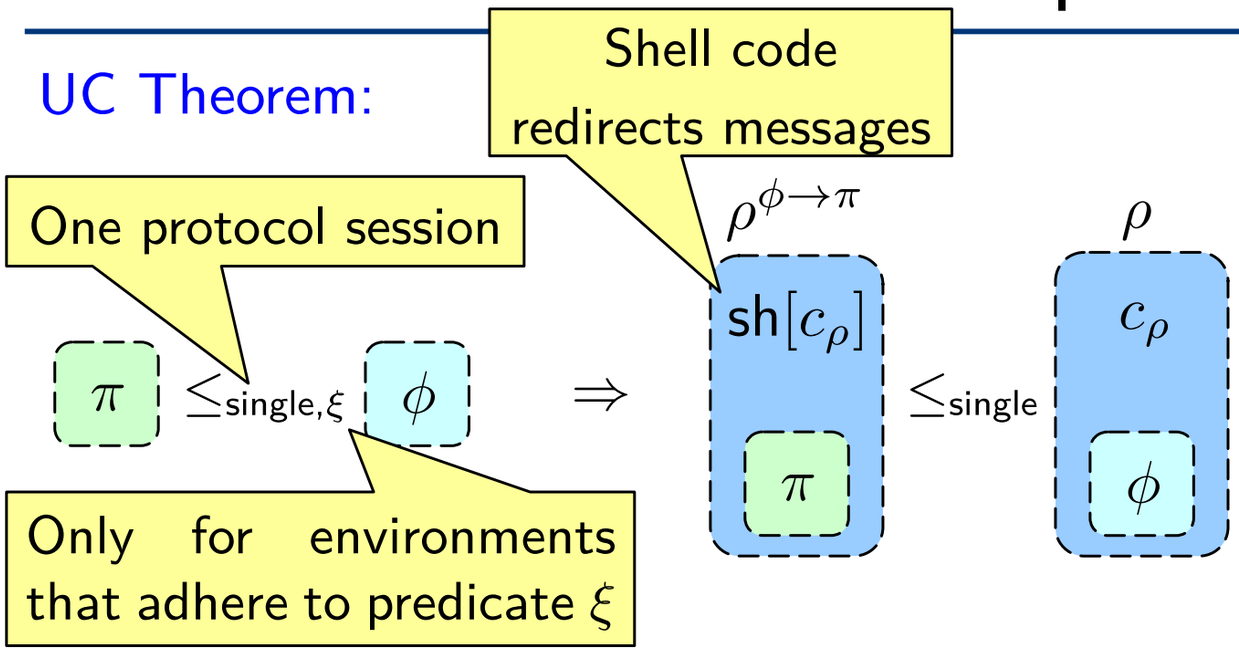

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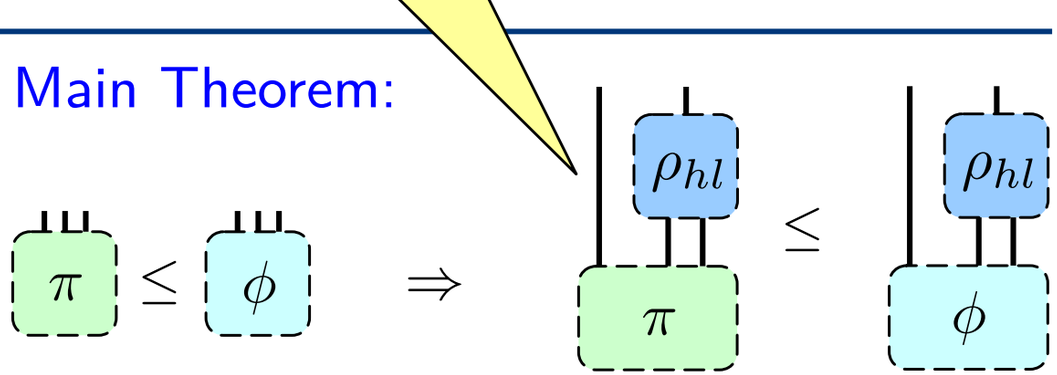

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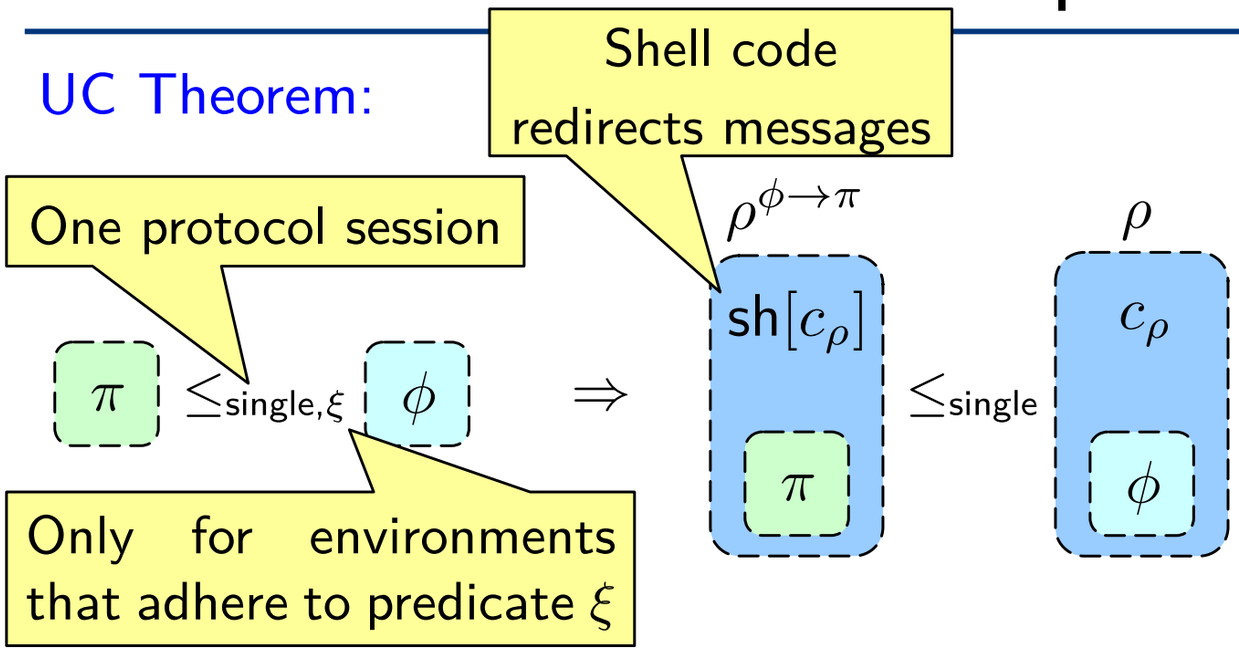

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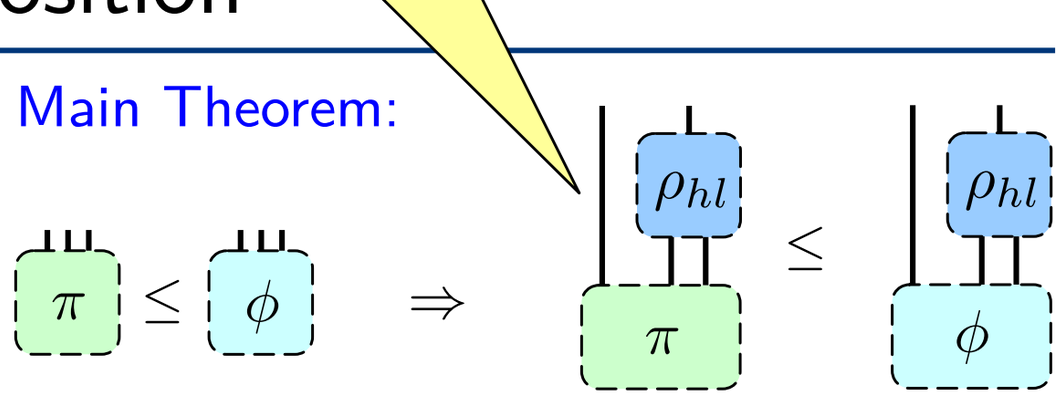

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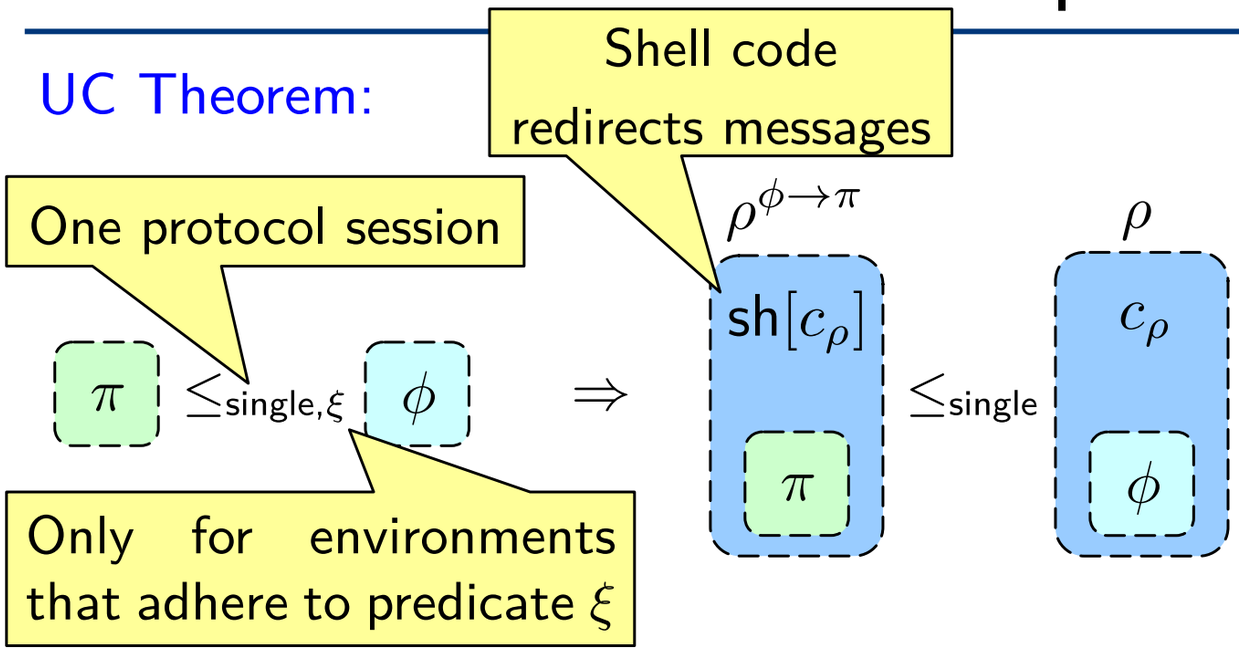

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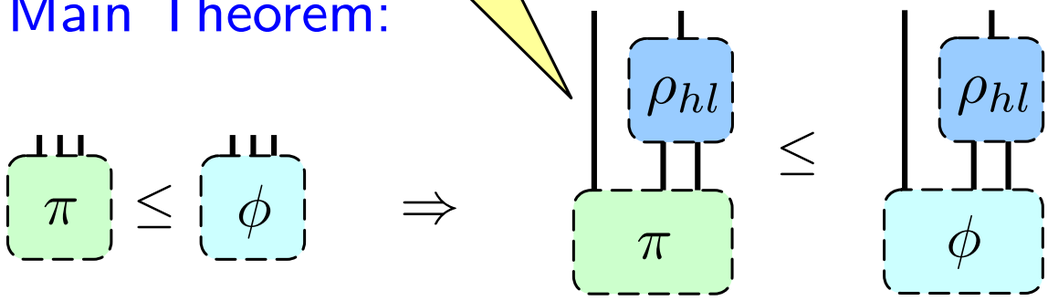

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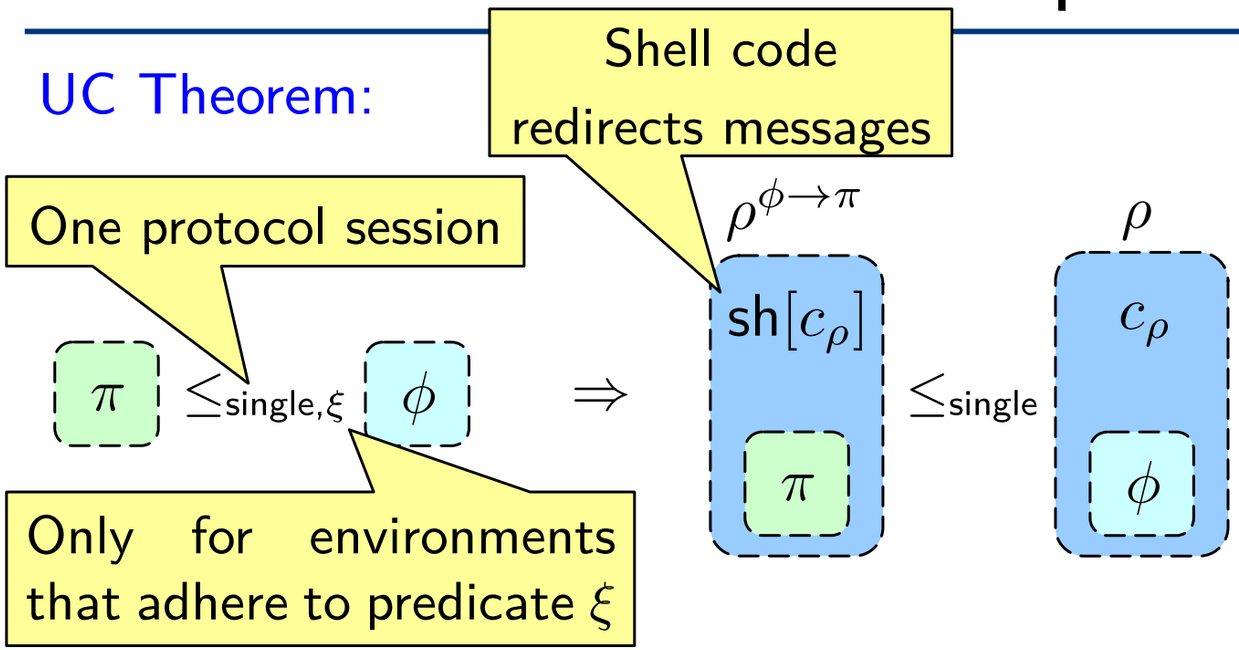

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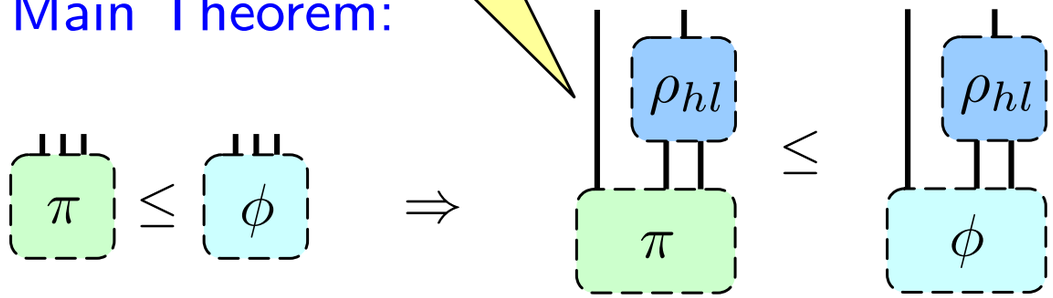

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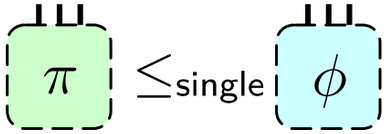

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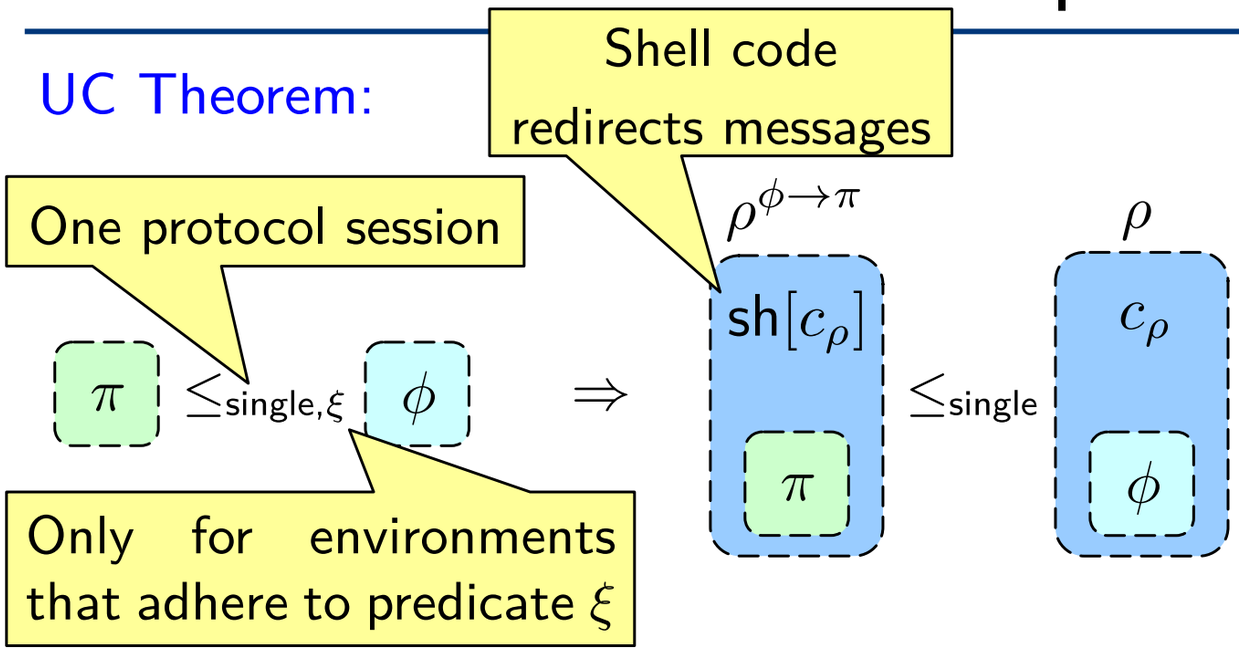

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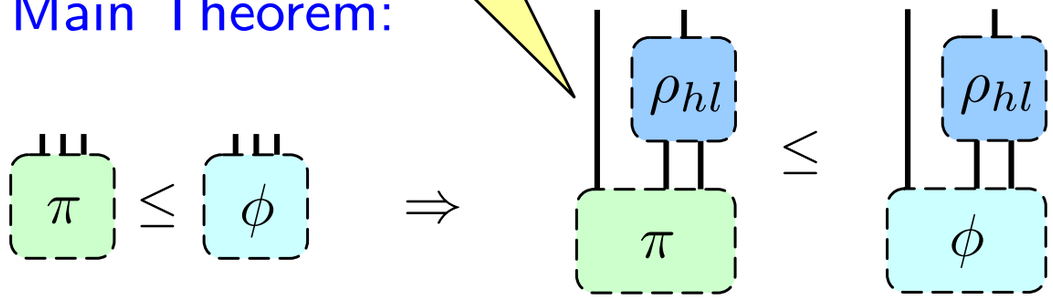

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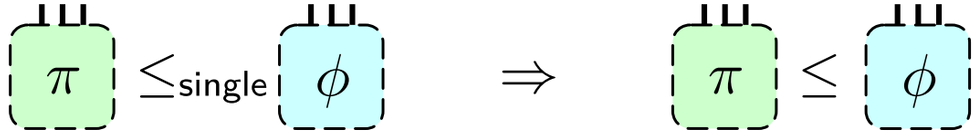

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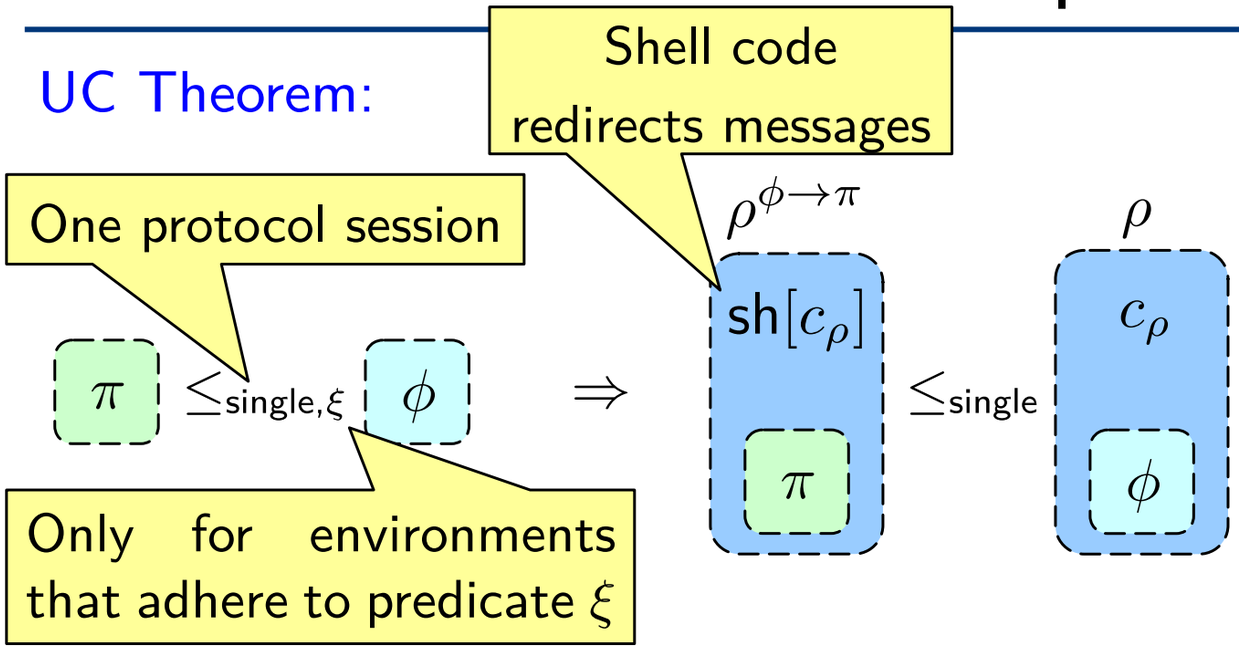

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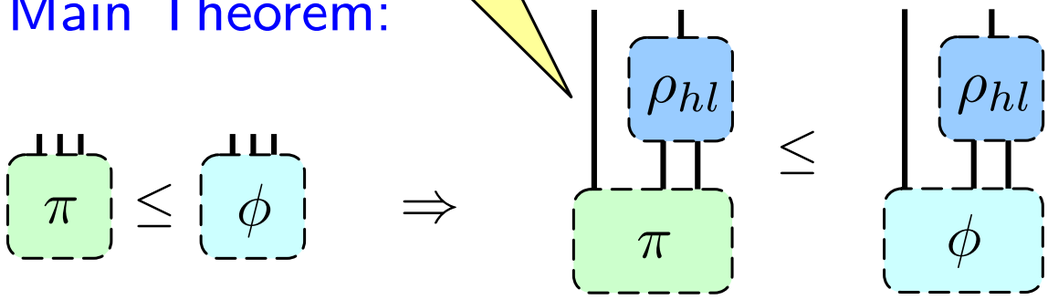

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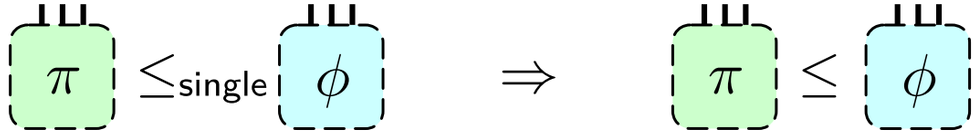

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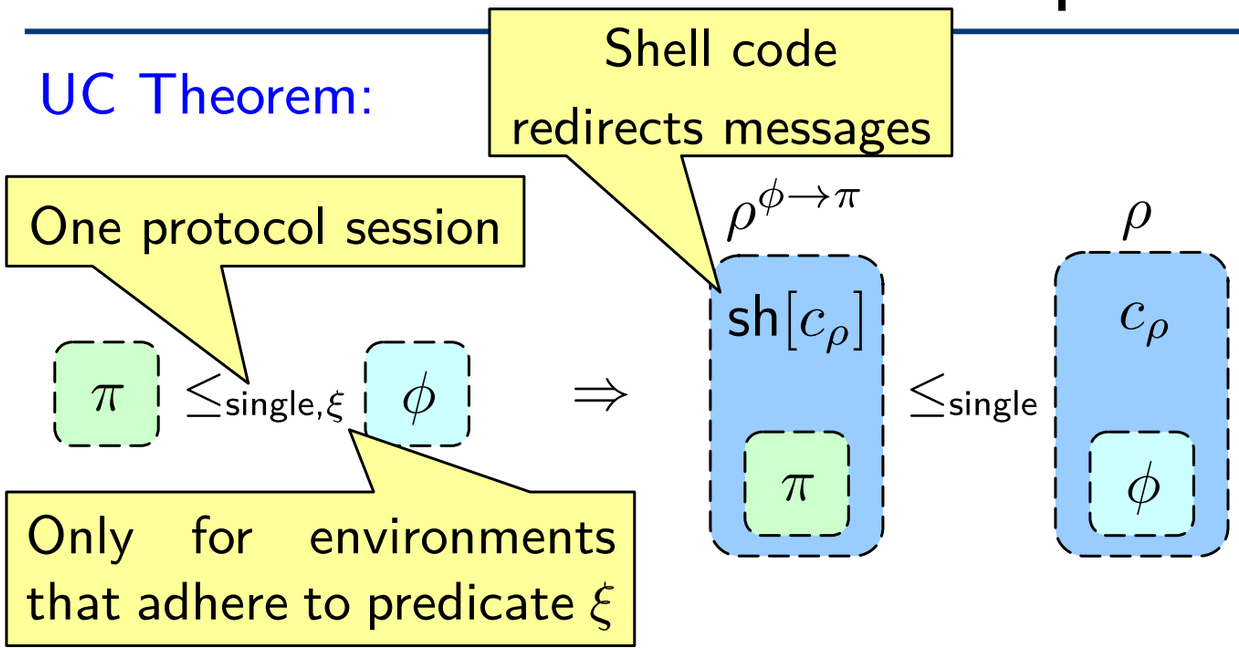

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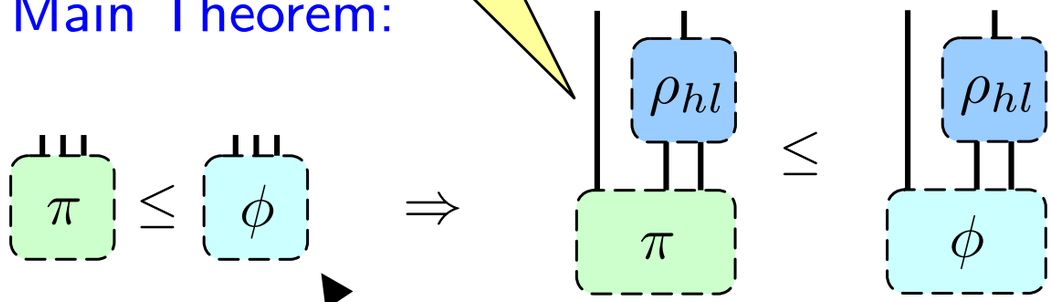

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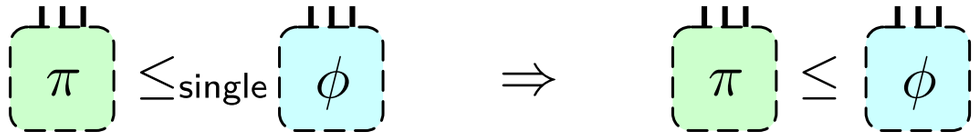

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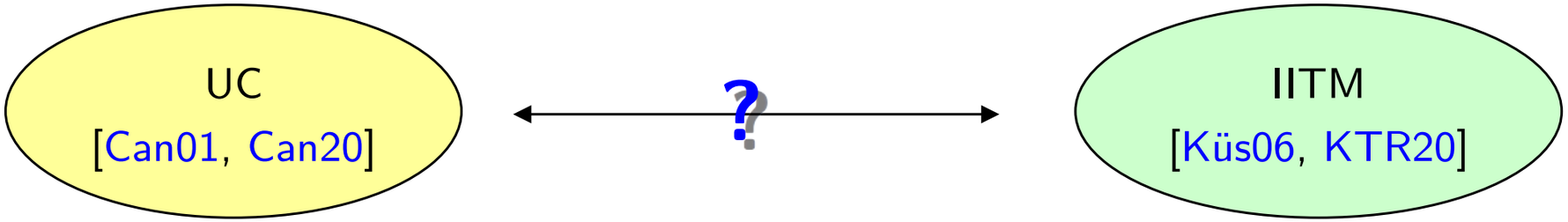

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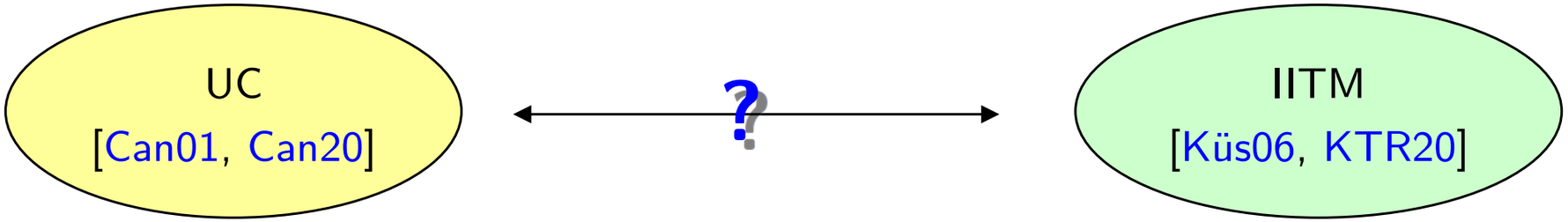

Different...

- computational frameworks
- compositional statements
- classes of environments, adversaries/simulators, protocols

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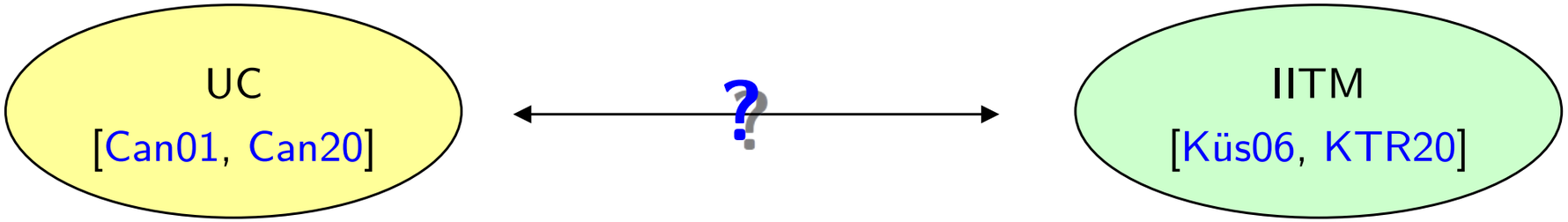

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How do models relate?

Are protocols and security results even comparable?

Main Contributions

- Concepts of UC and IITM
- **Embedding UC into IITM**
- The Other Direction

From UC to IITM Protocols

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- Variant $\pi_{IITM}^{\xi\text{-id}}$ that enforces a ξ bound on arbitrary environments

Preserving Security

Theorem:

$$\pi_{\mathsf{UC}} \leq_{\mathsf{single},\xi} \phi_{\mathsf{UC}}$$

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$$\pi_{\mathsf{UC}} \leq_{\mathsf{single},\xi} \phi_{\mathsf{UC}} \quad \Rightarrow \quad \pi^{\xi\text{-id}}_{\mathsf{IITM}} \leq \phi^{\xi\text{-id}}_{\mathsf{IITM}}$$

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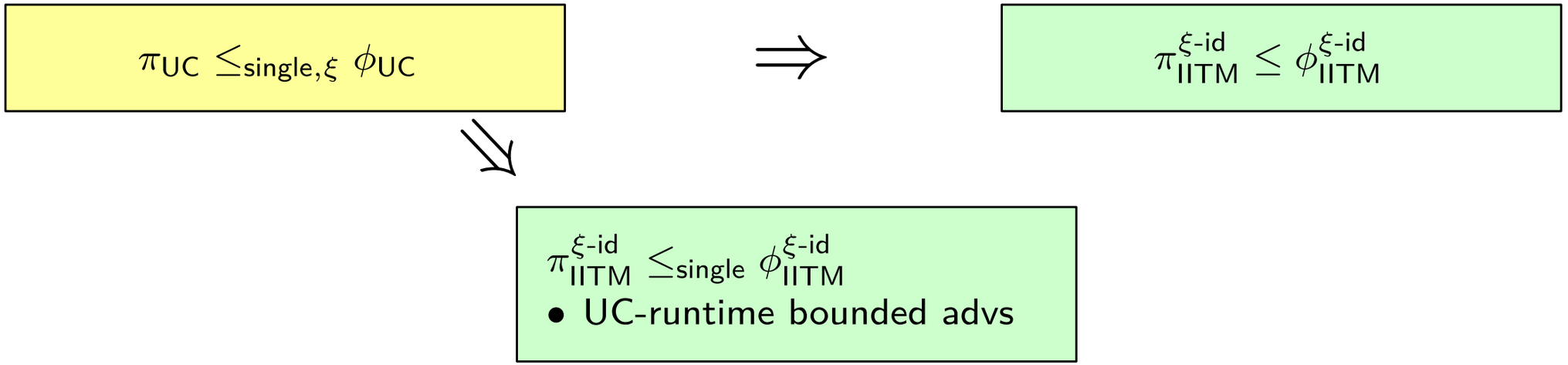

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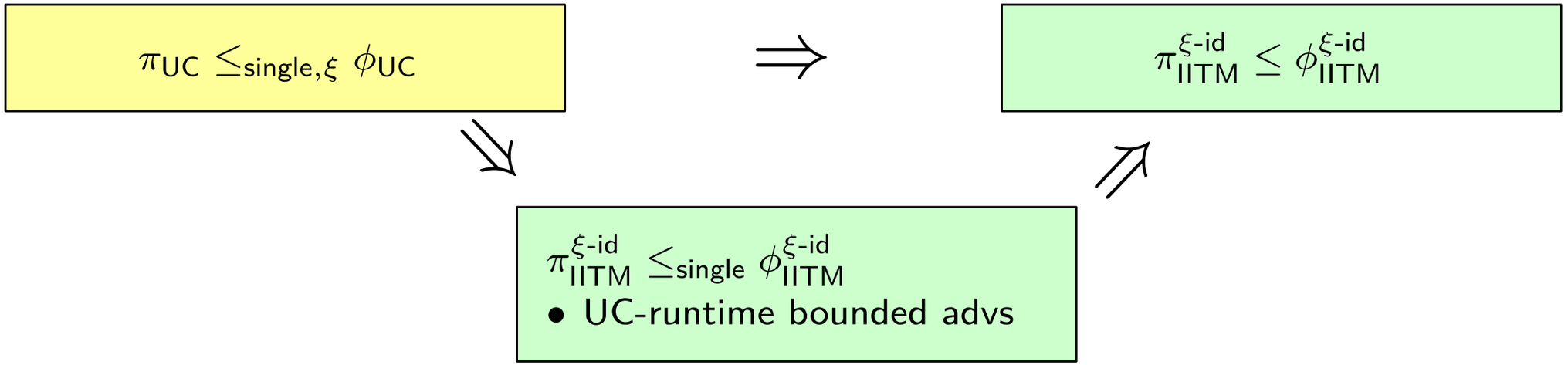

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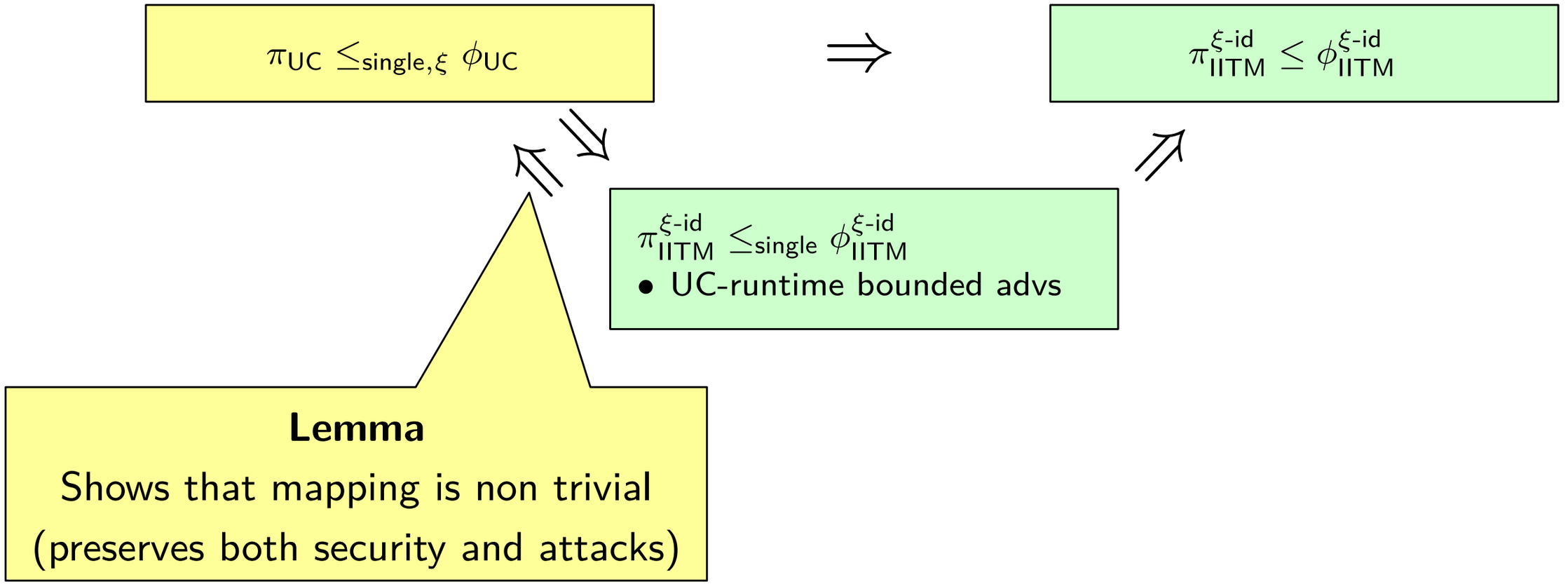

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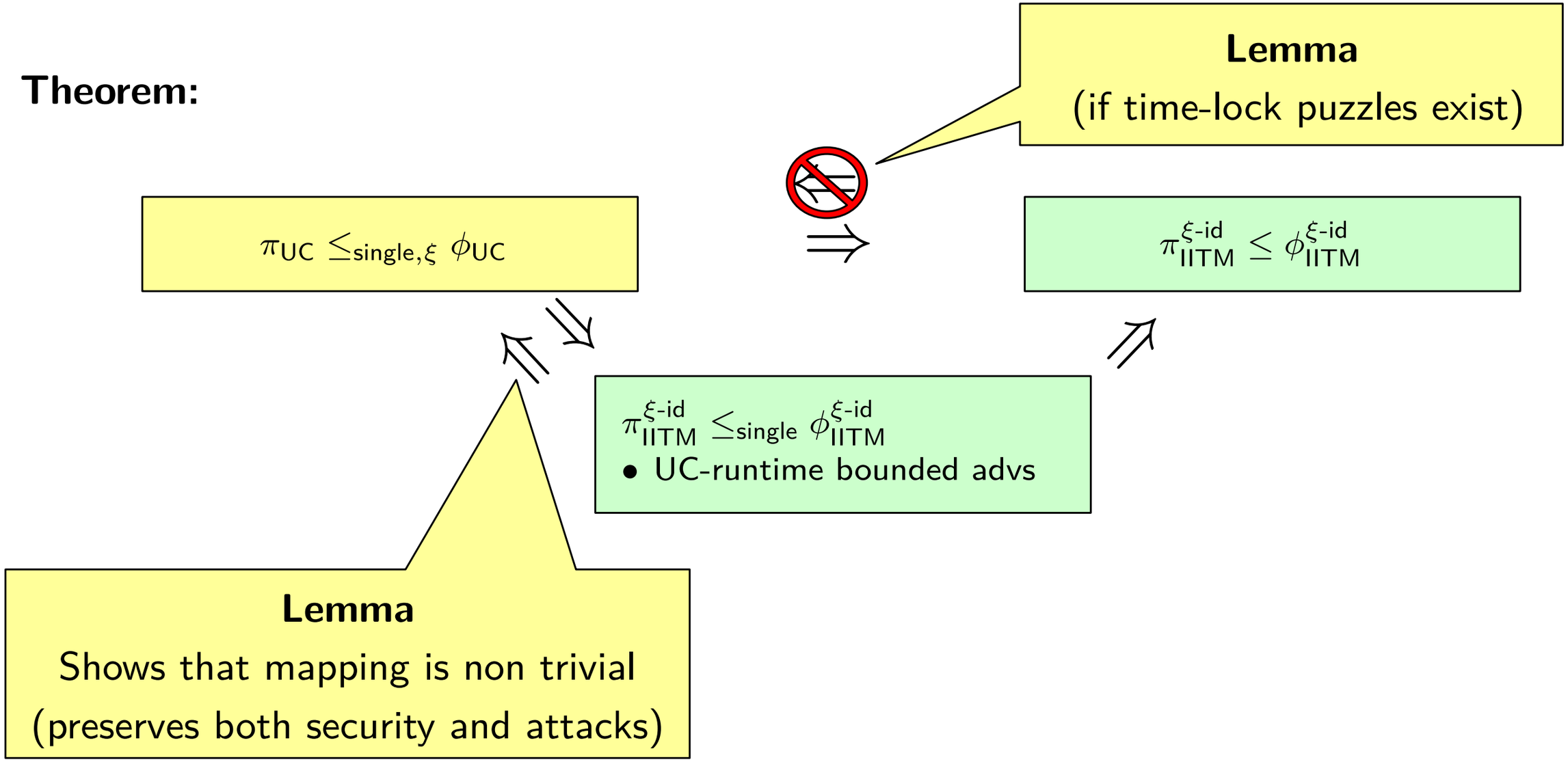

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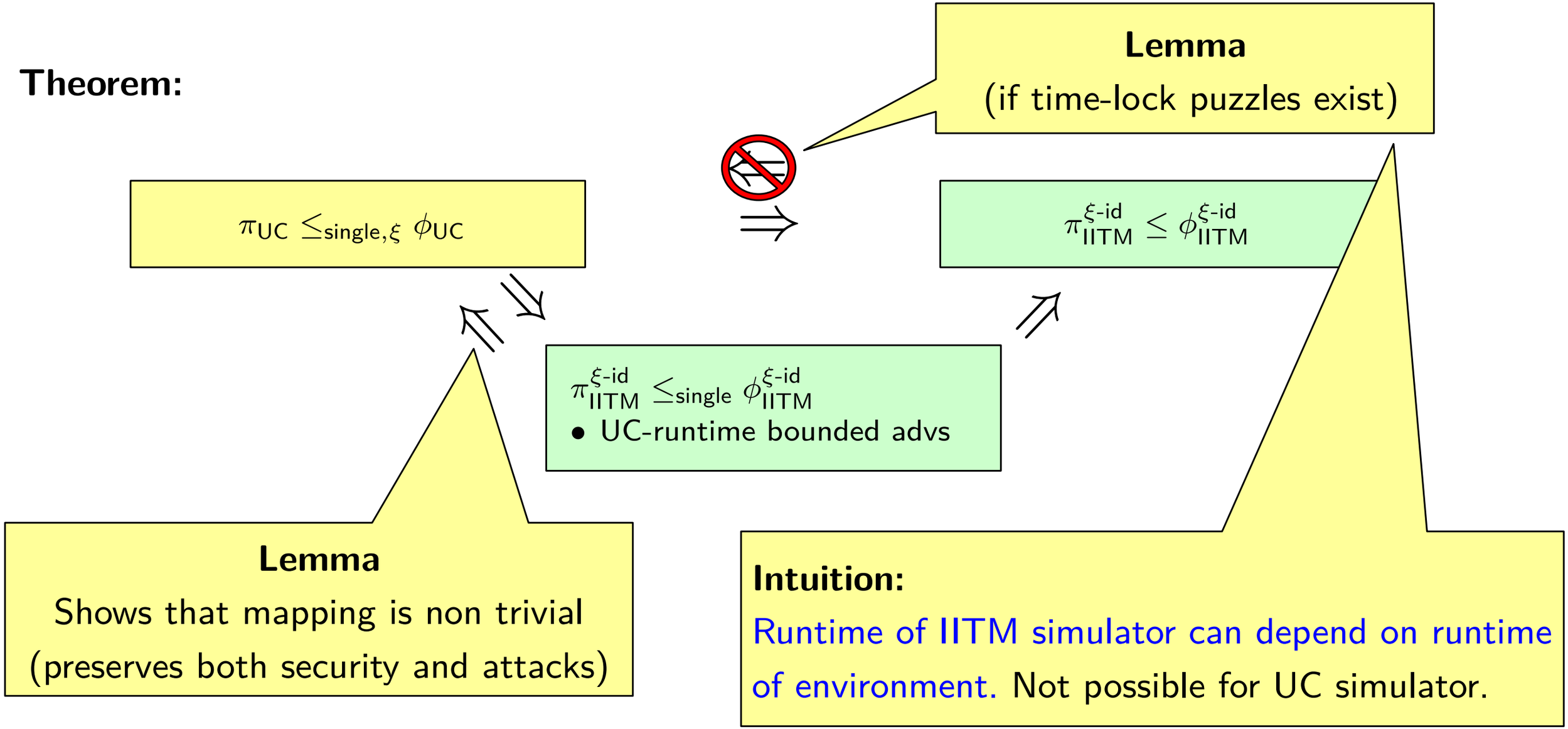

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Corollary: UC composition results also carry over

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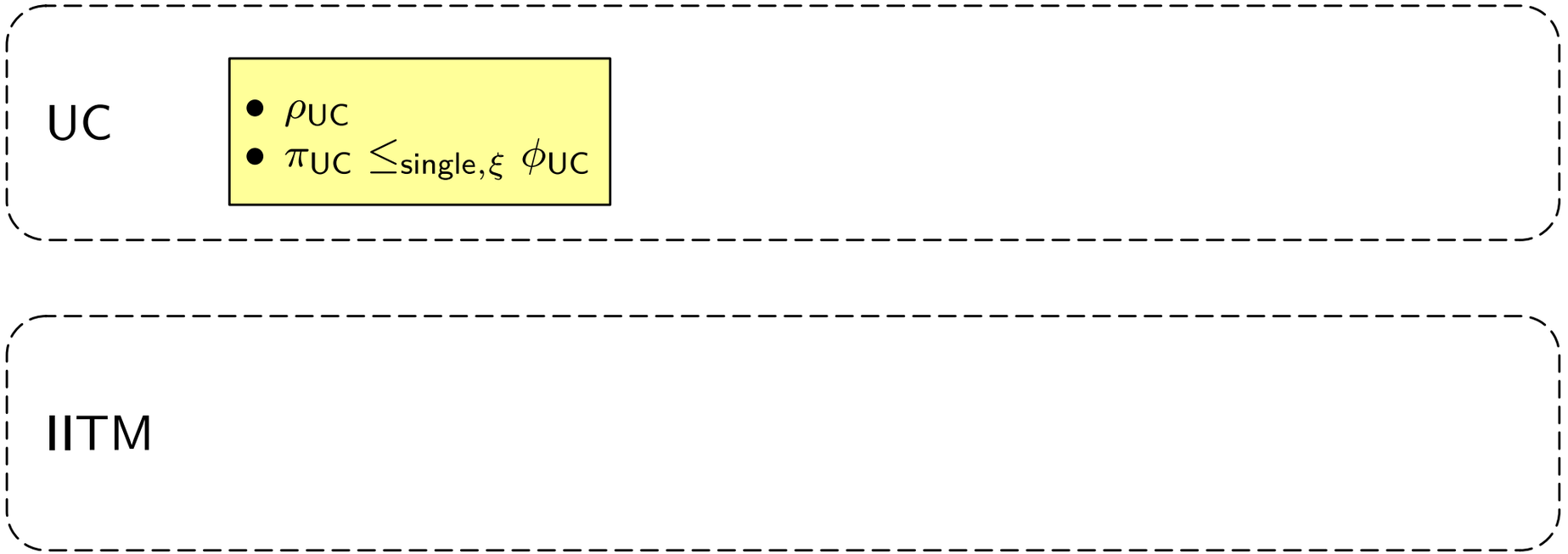

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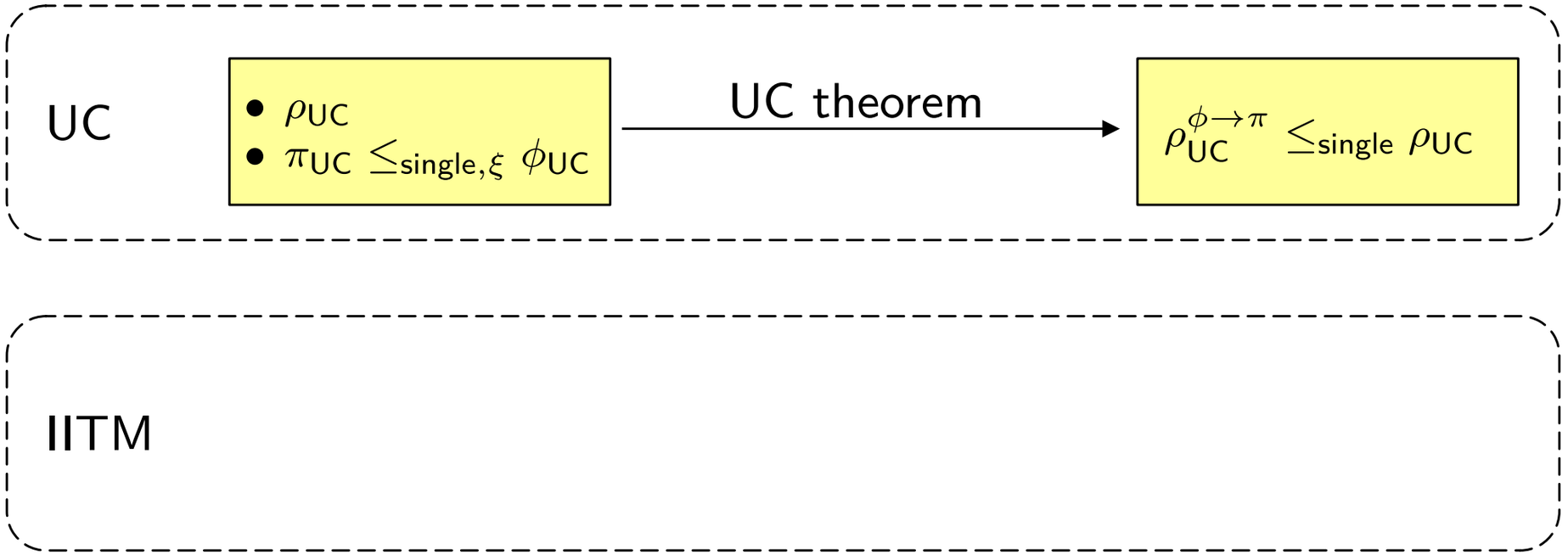

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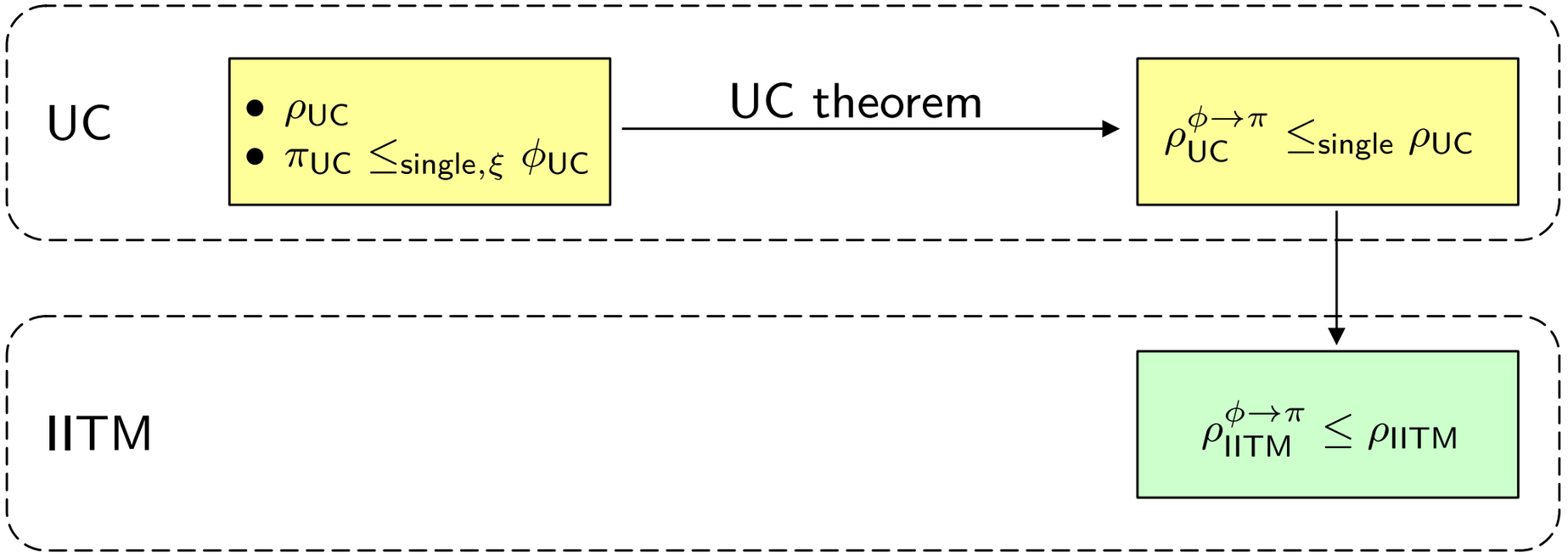

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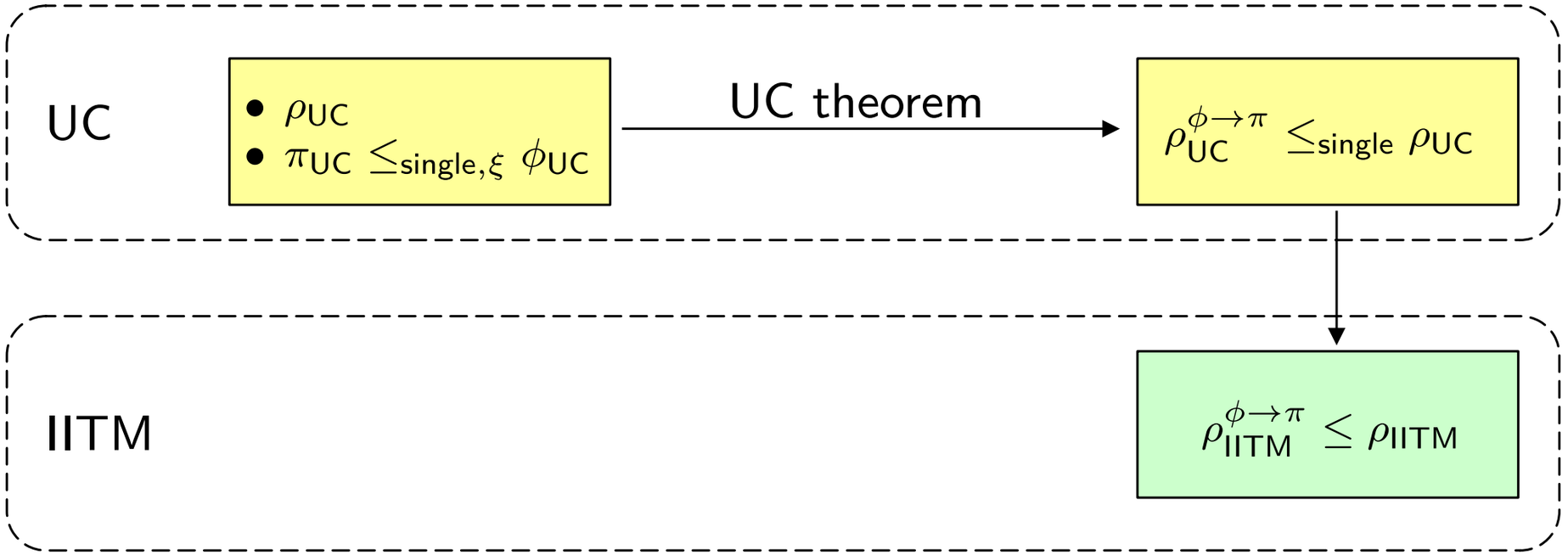

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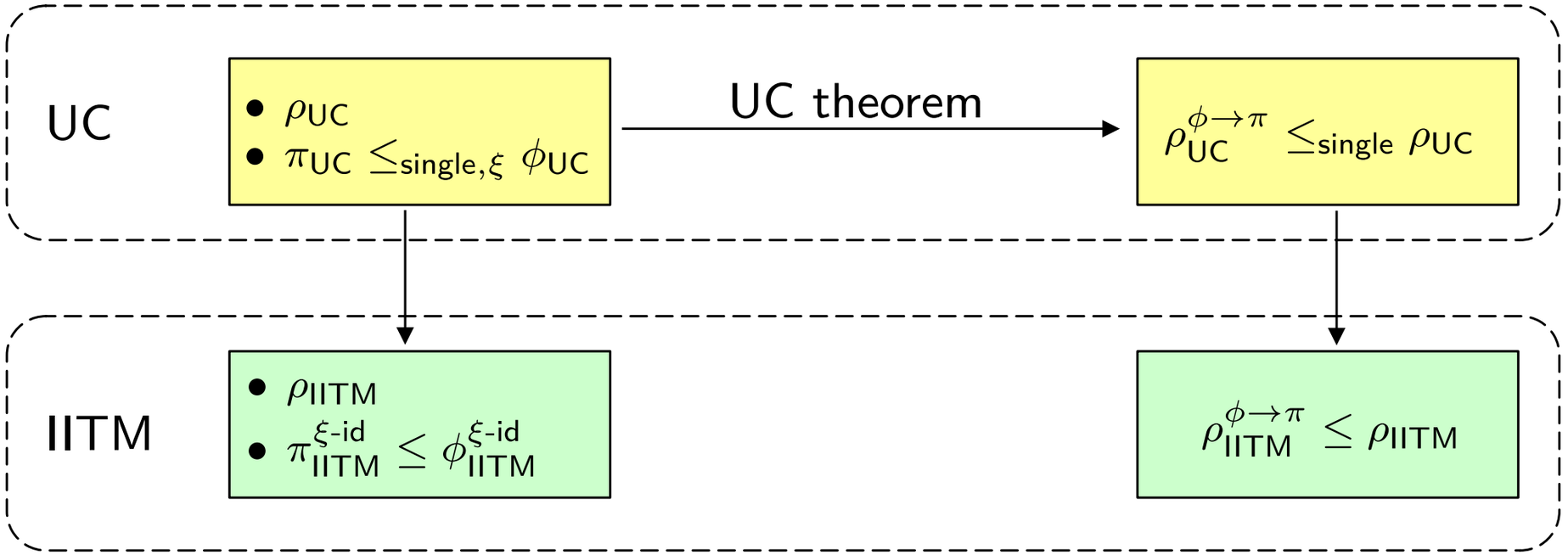

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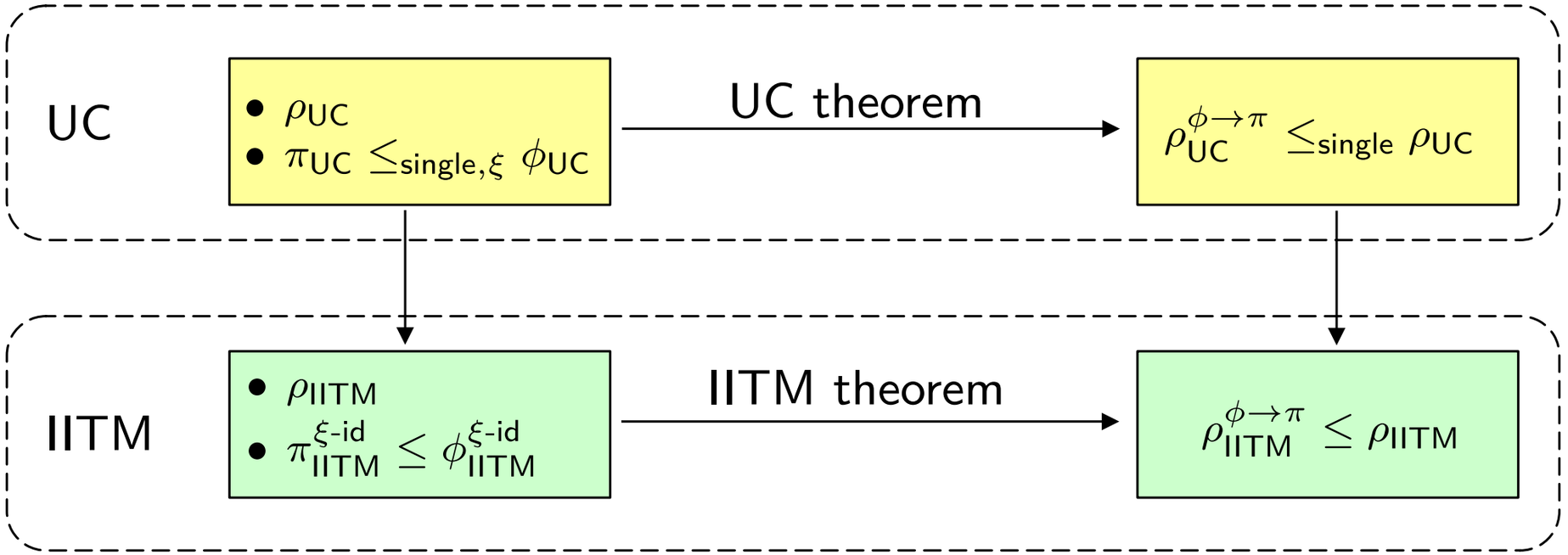

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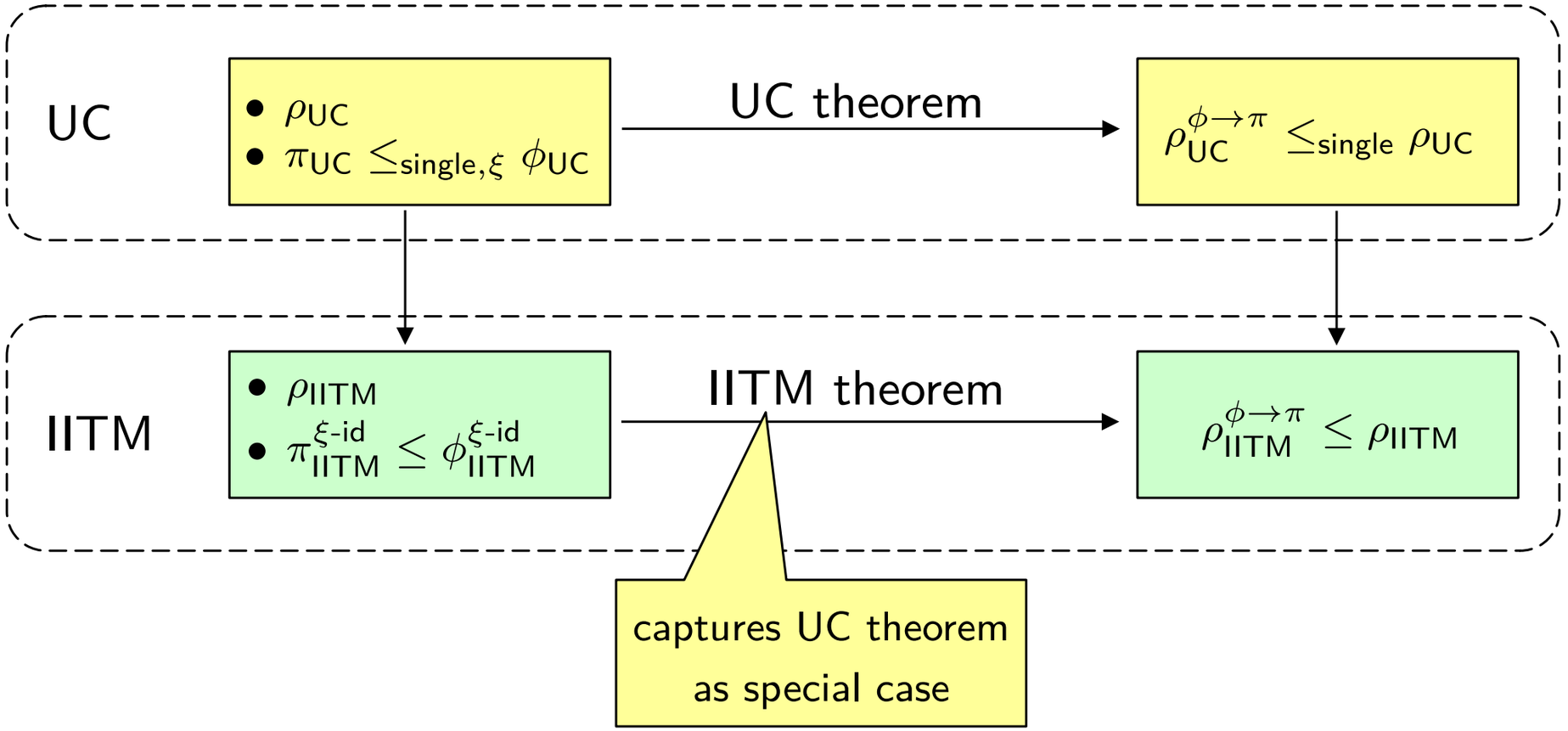

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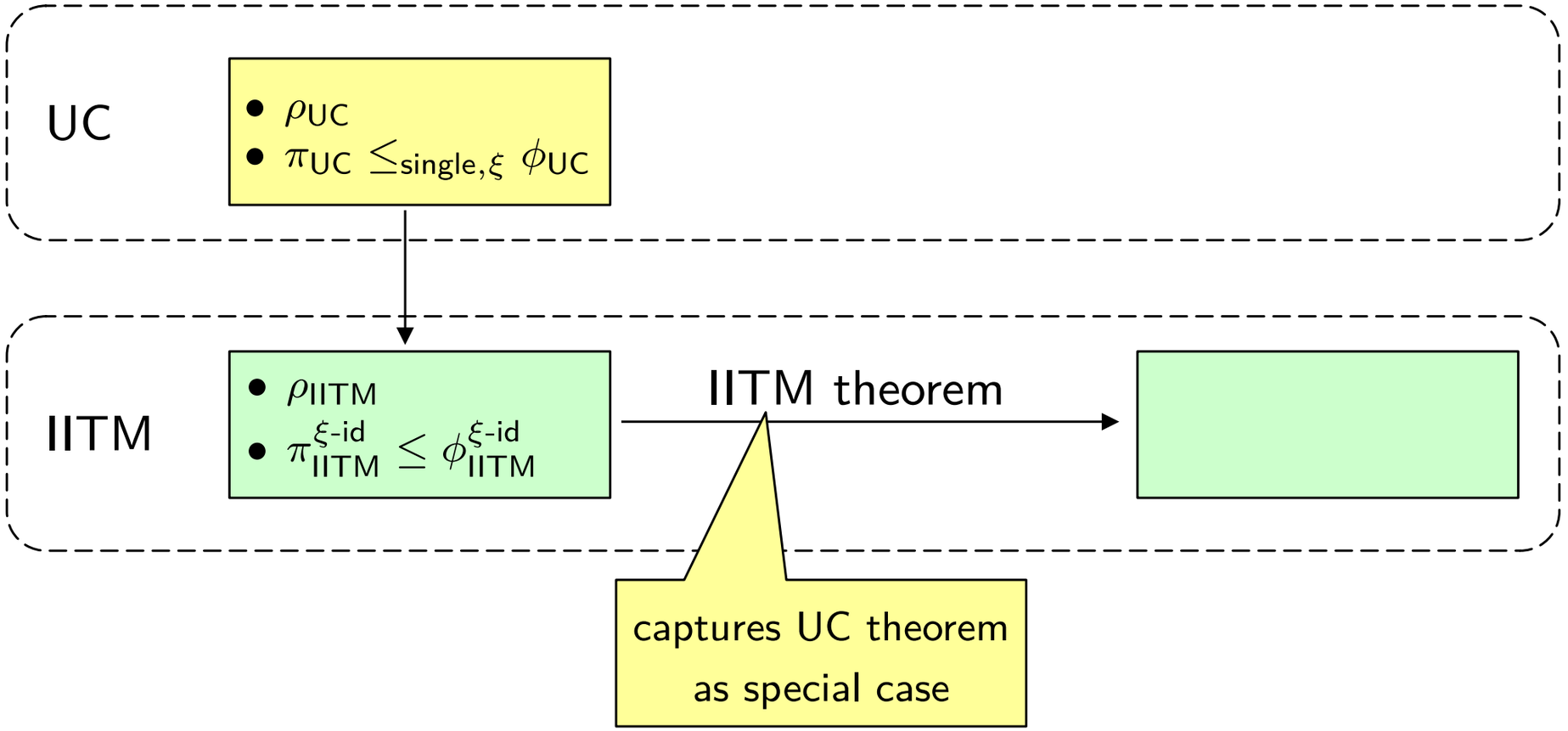

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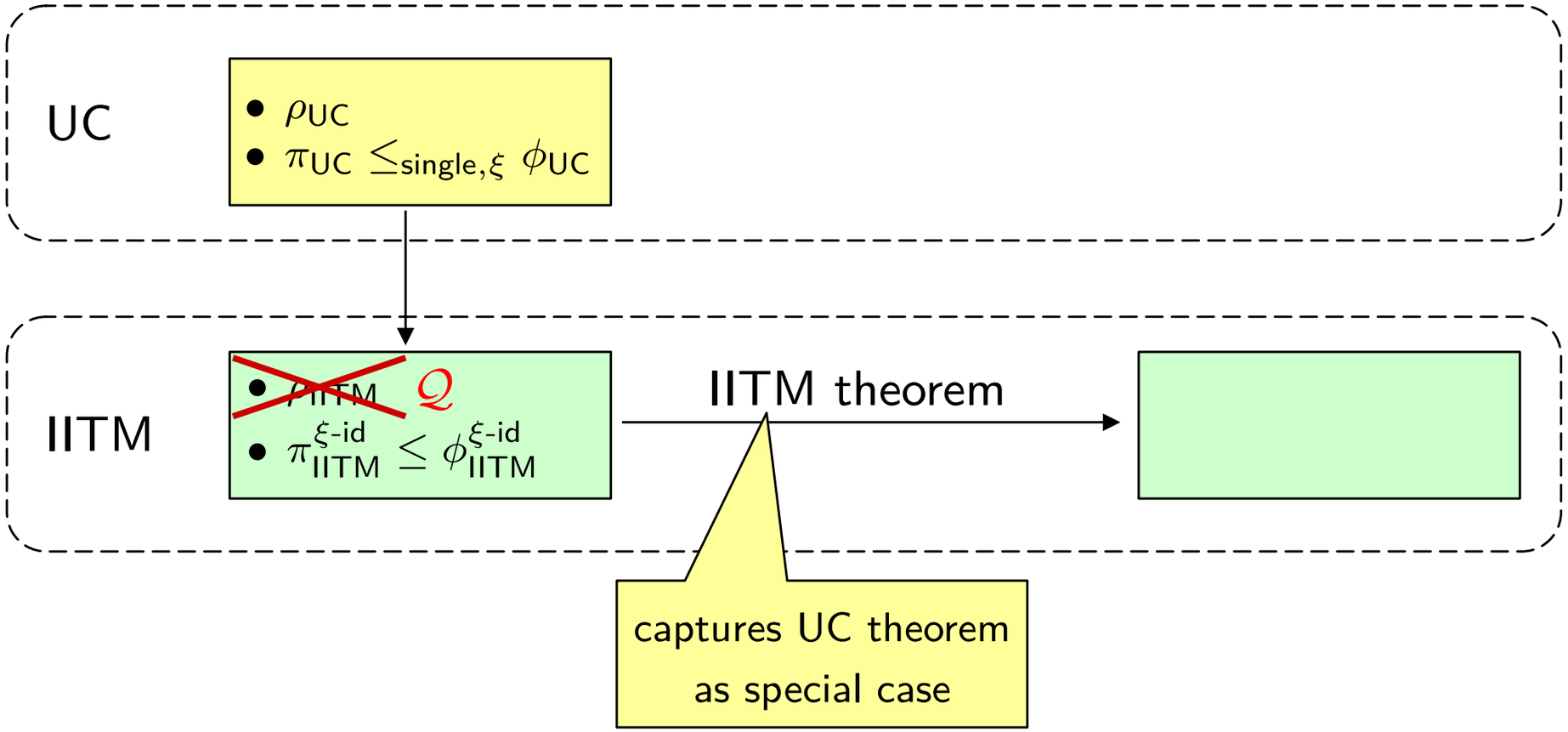

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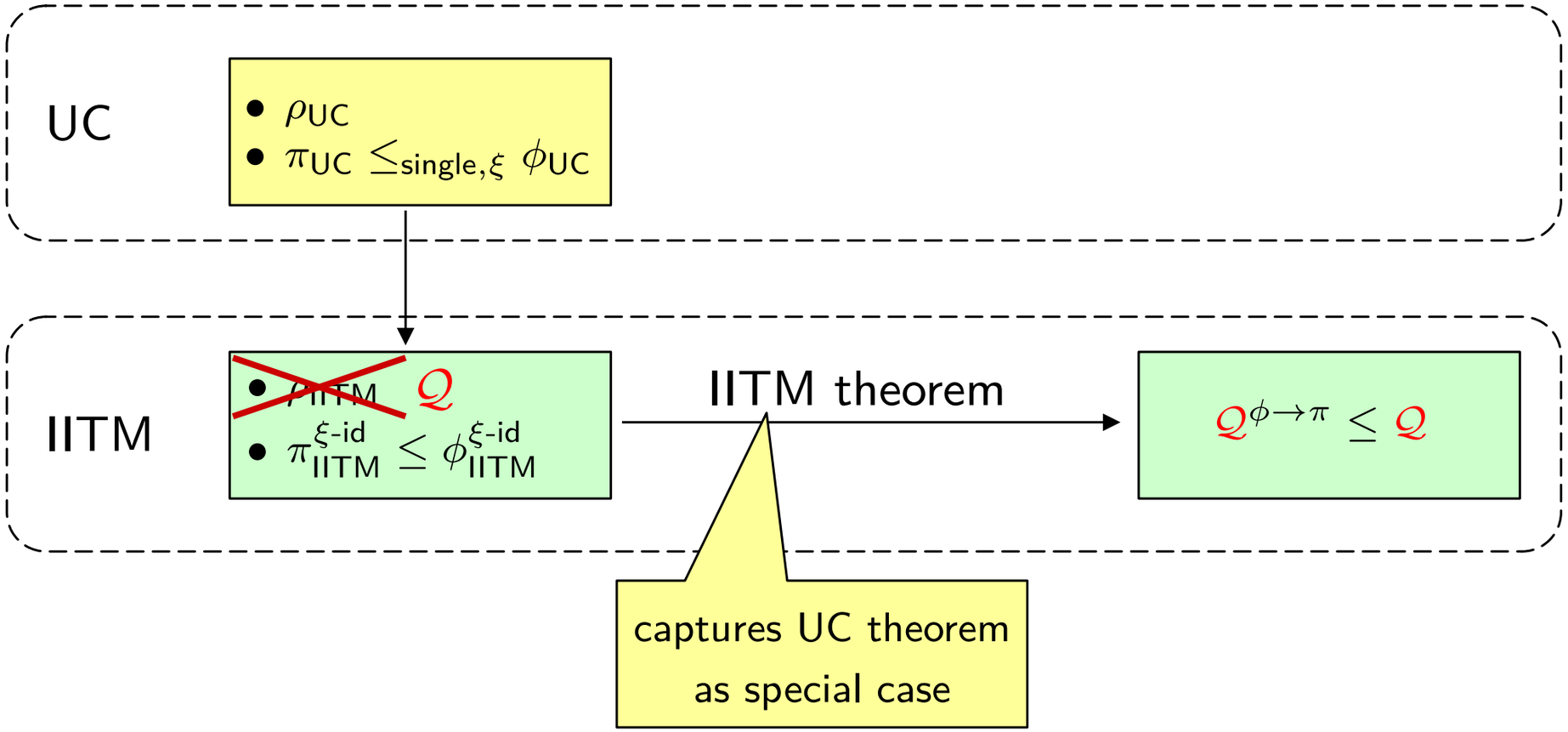
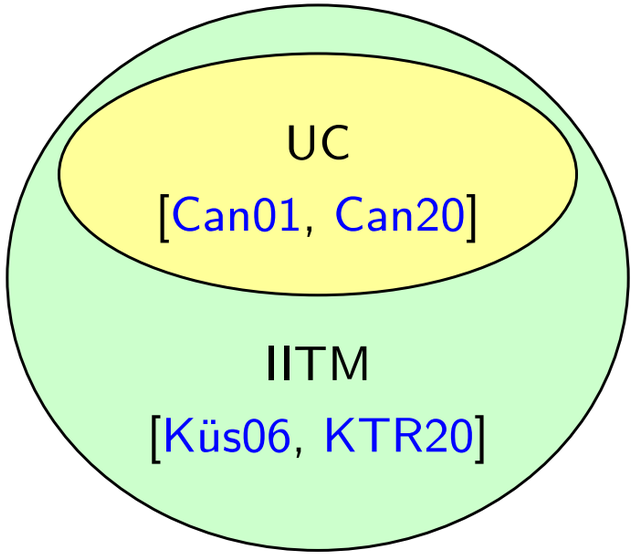


Main Contributions

- Concepts of UC and IITM
- Embedding UC into IITM
- **The Other Direction**

From IITM to UC

The other direction is impossible in general:



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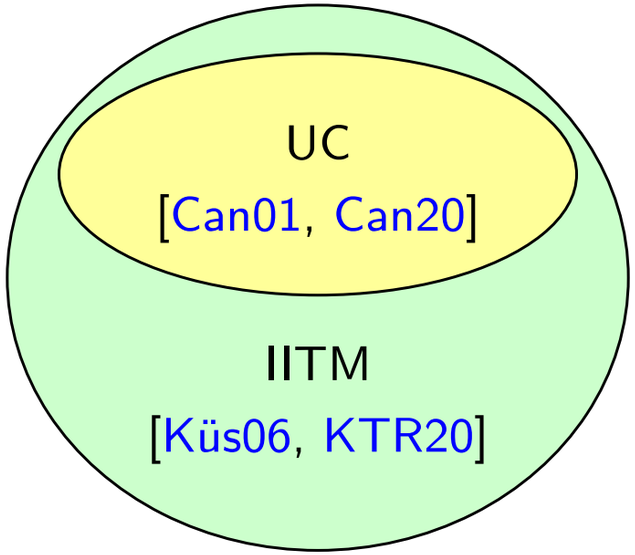

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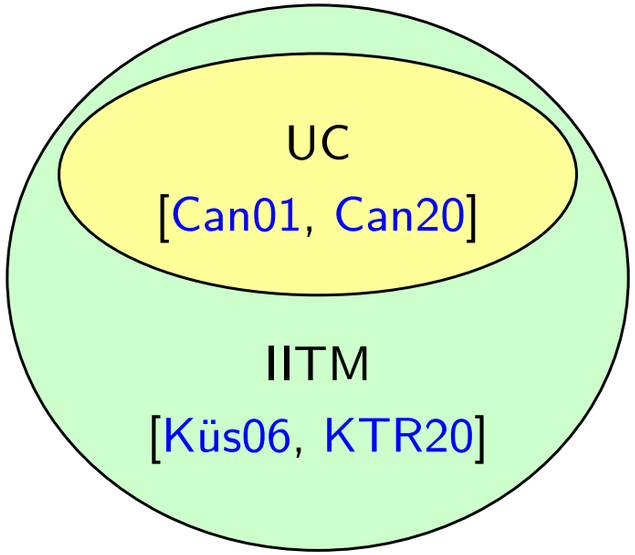

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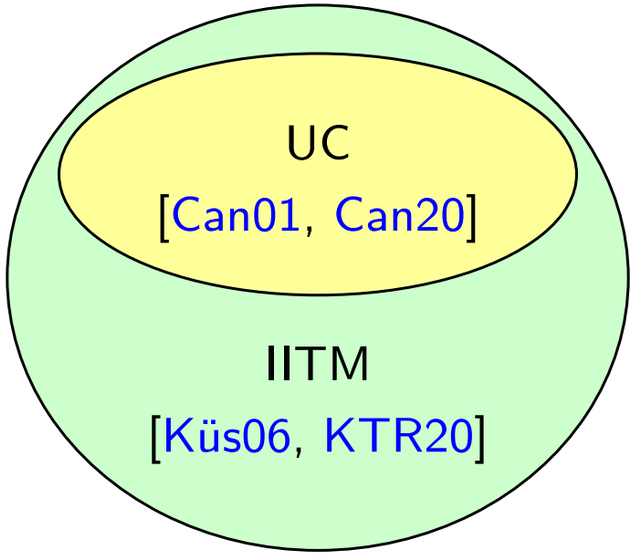
- UC protocols must provide an oracle that reveals existence of instances to adversary
  - Changes security properties



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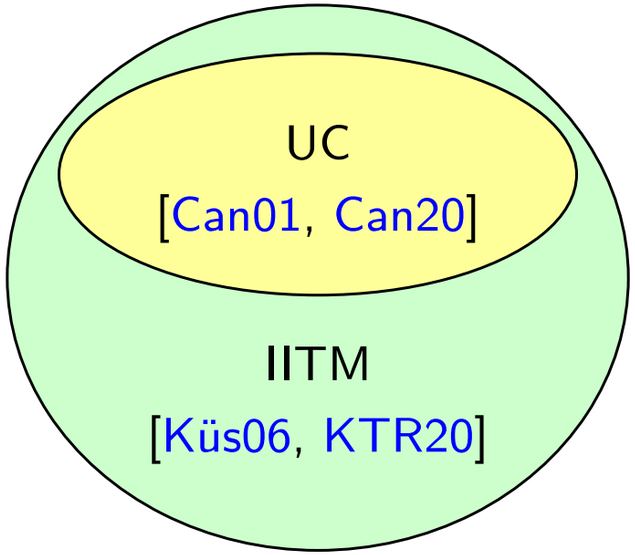

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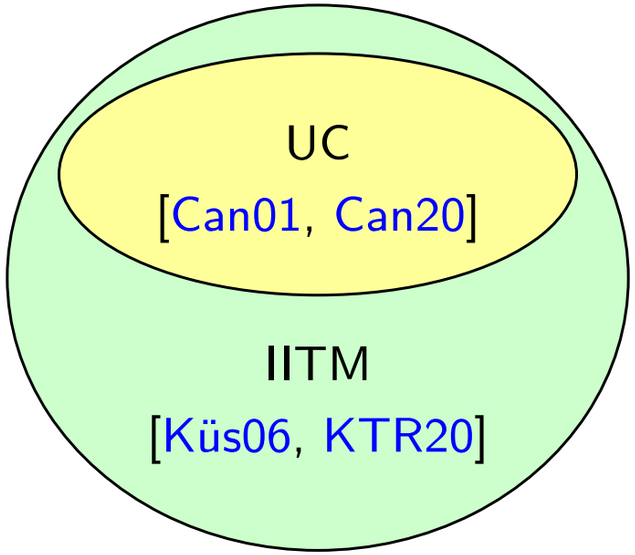

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  Existing UC results can benefit from IITM features such as

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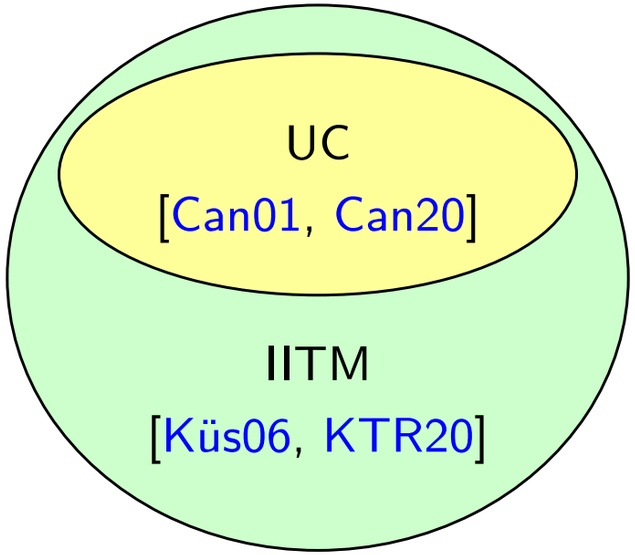

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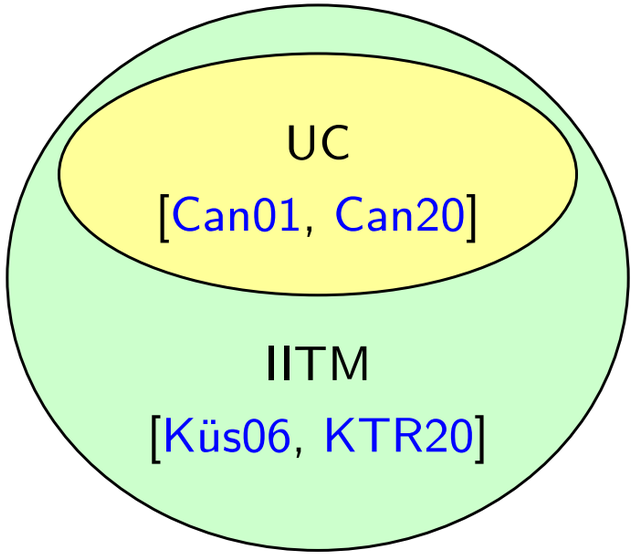

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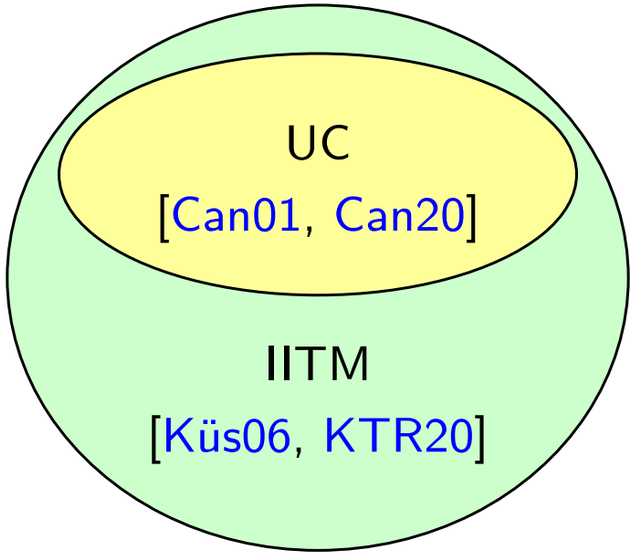
  Identify and map subset of IITM protocols/results to UC



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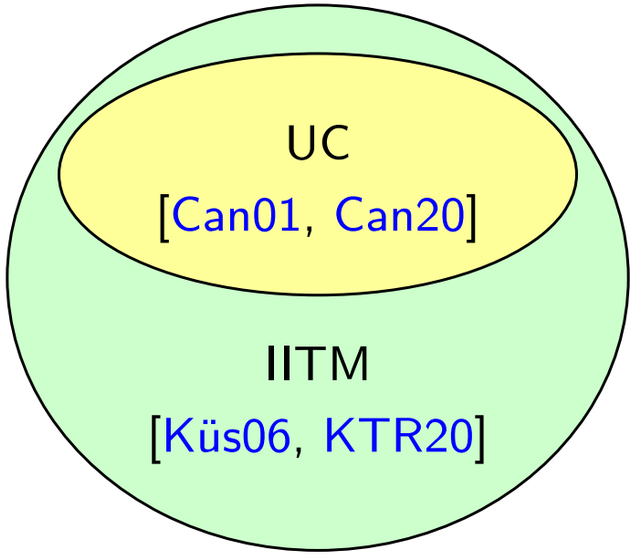

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