Inference-proof program-based mediation of data sources

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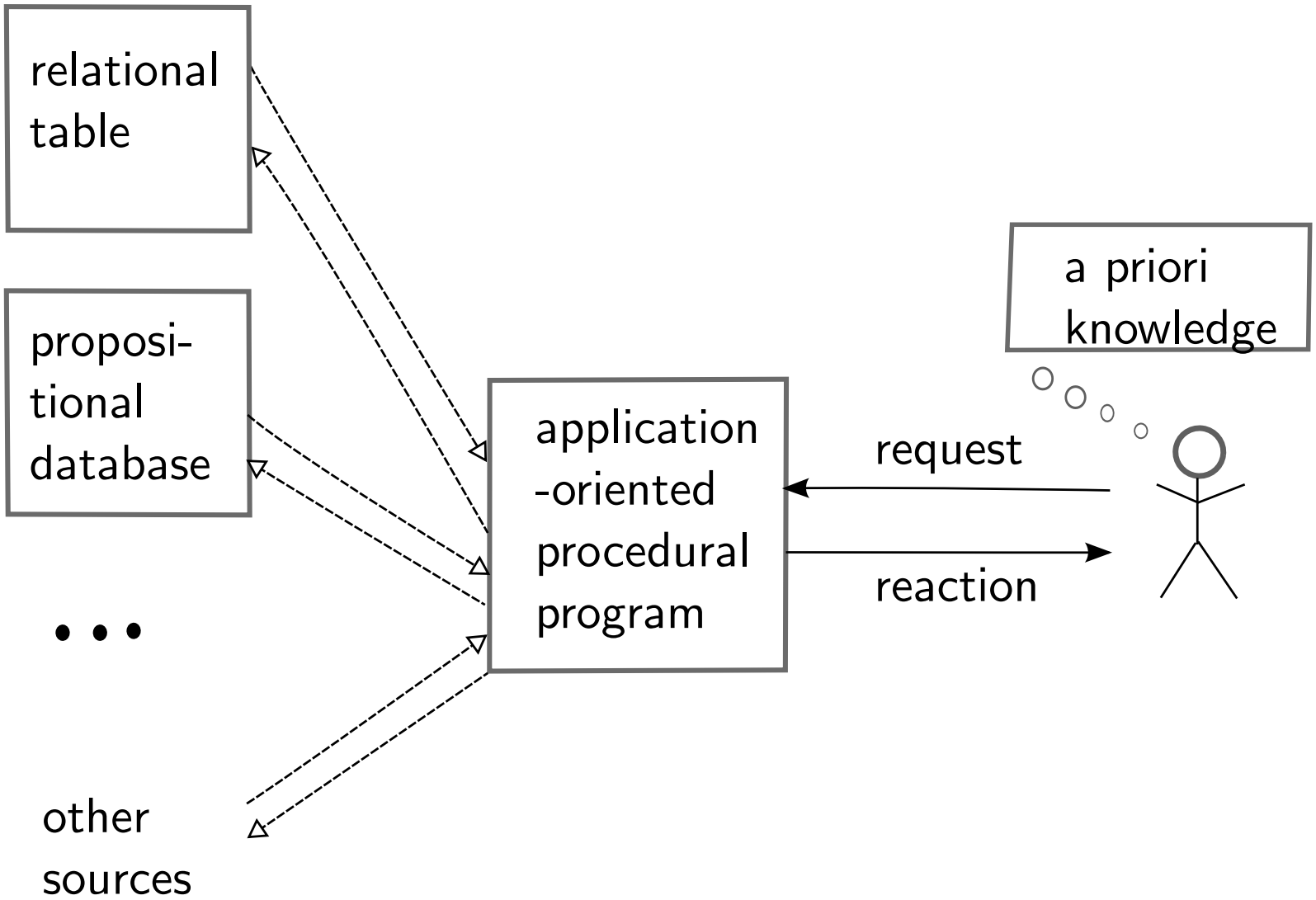
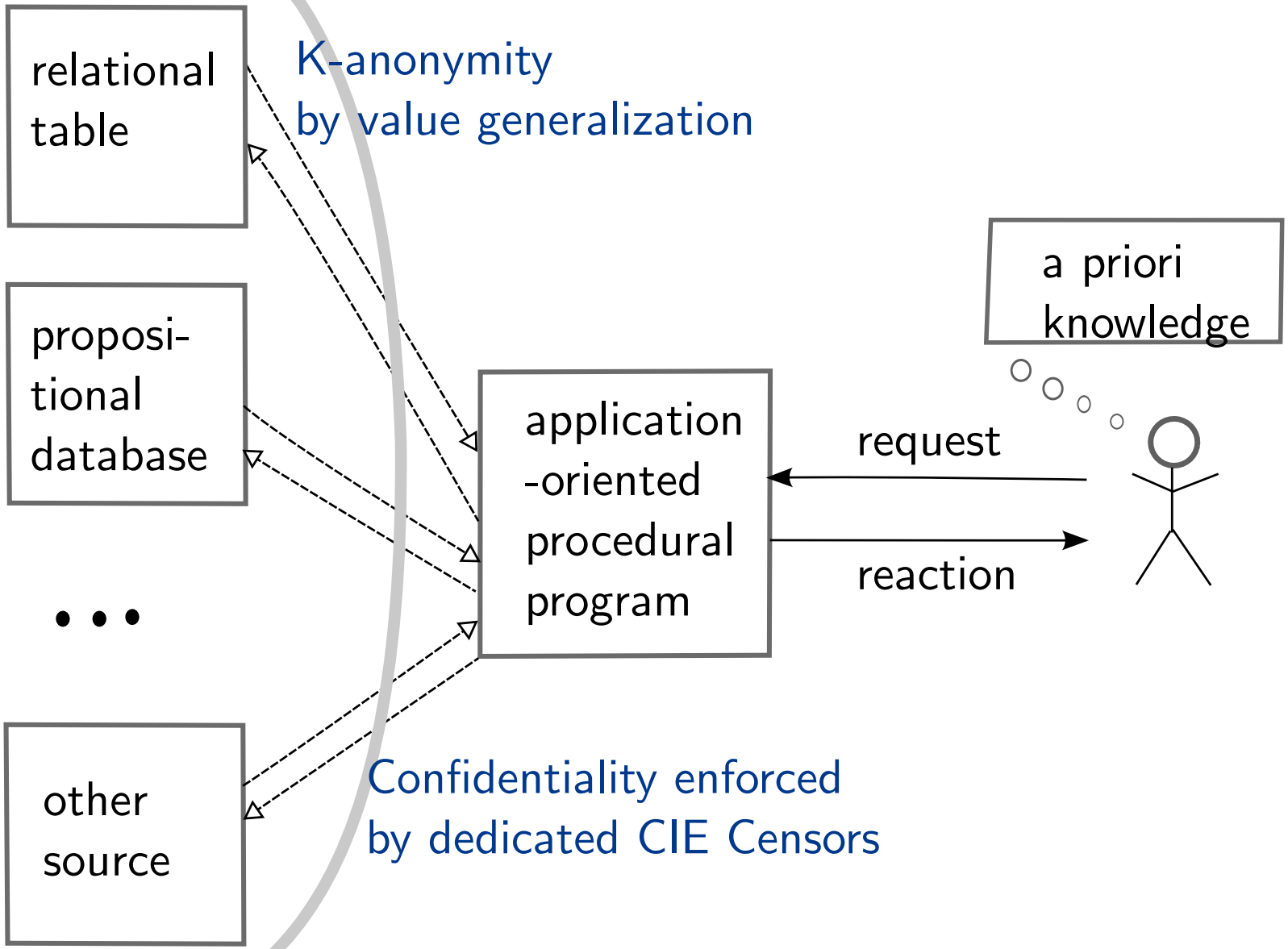
A Challenging Scenario



A Straightforward Solution



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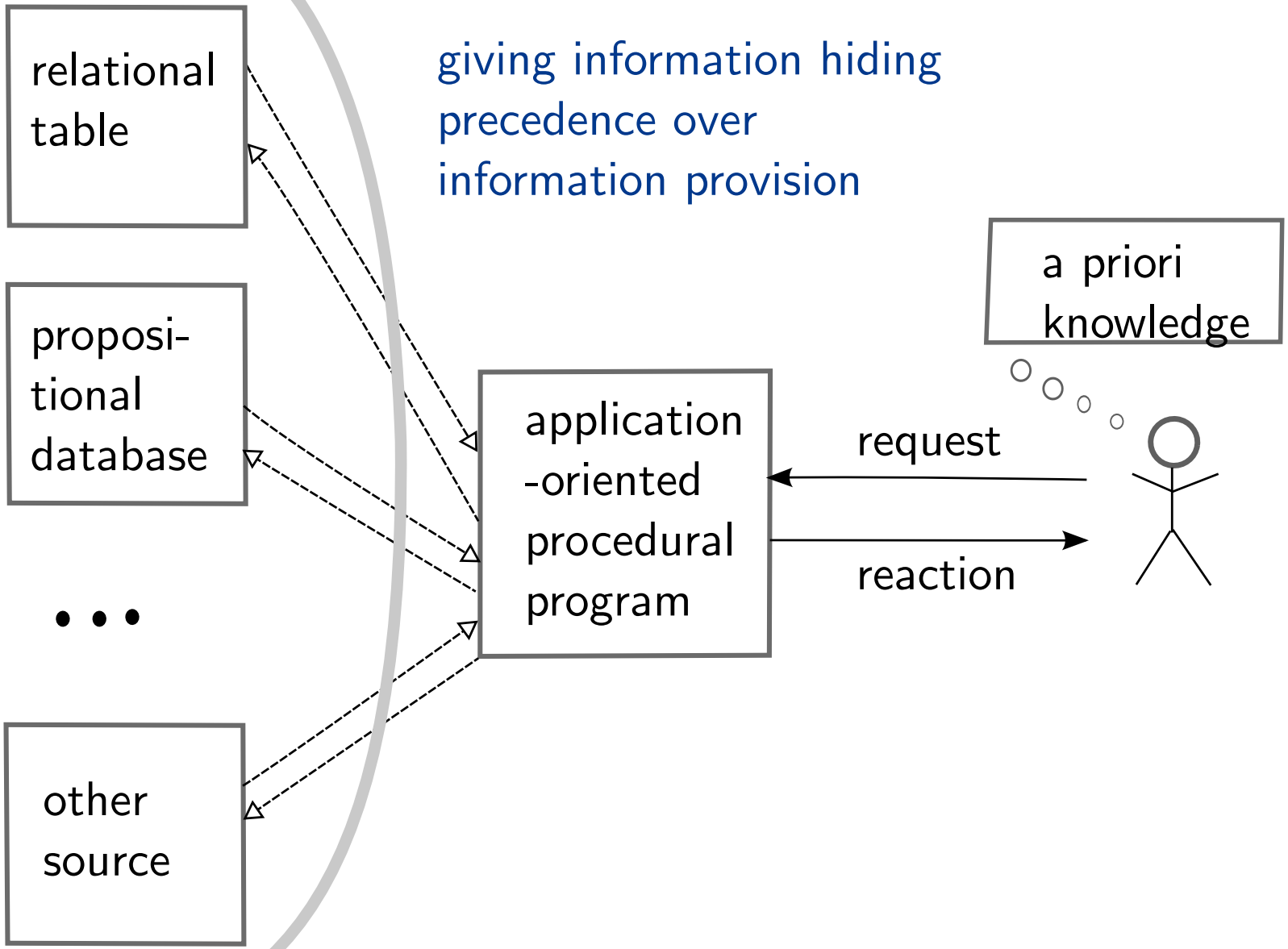
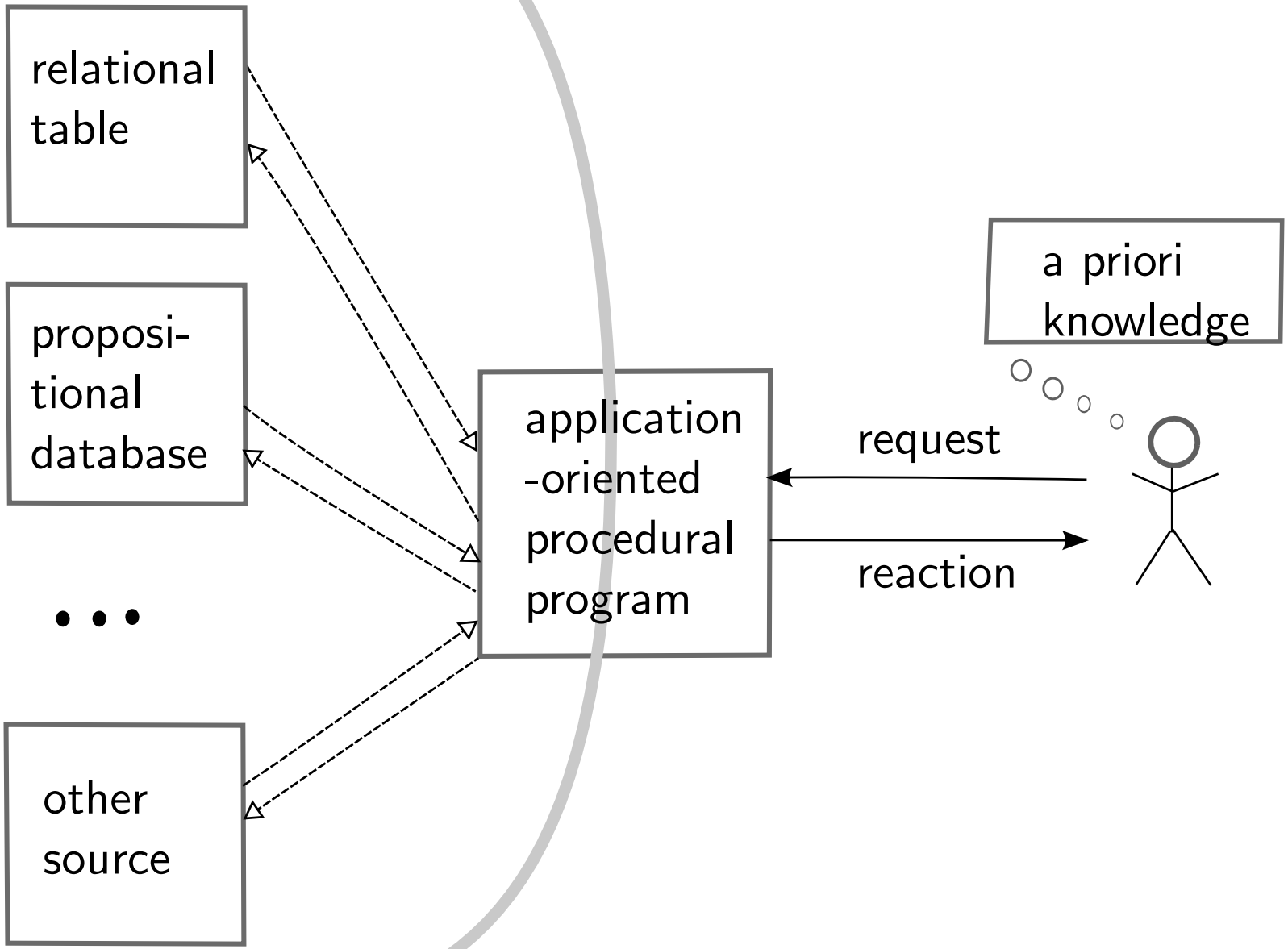


A Solution to Balance the Hiding/Provision Trade-Off



Existing Technologies

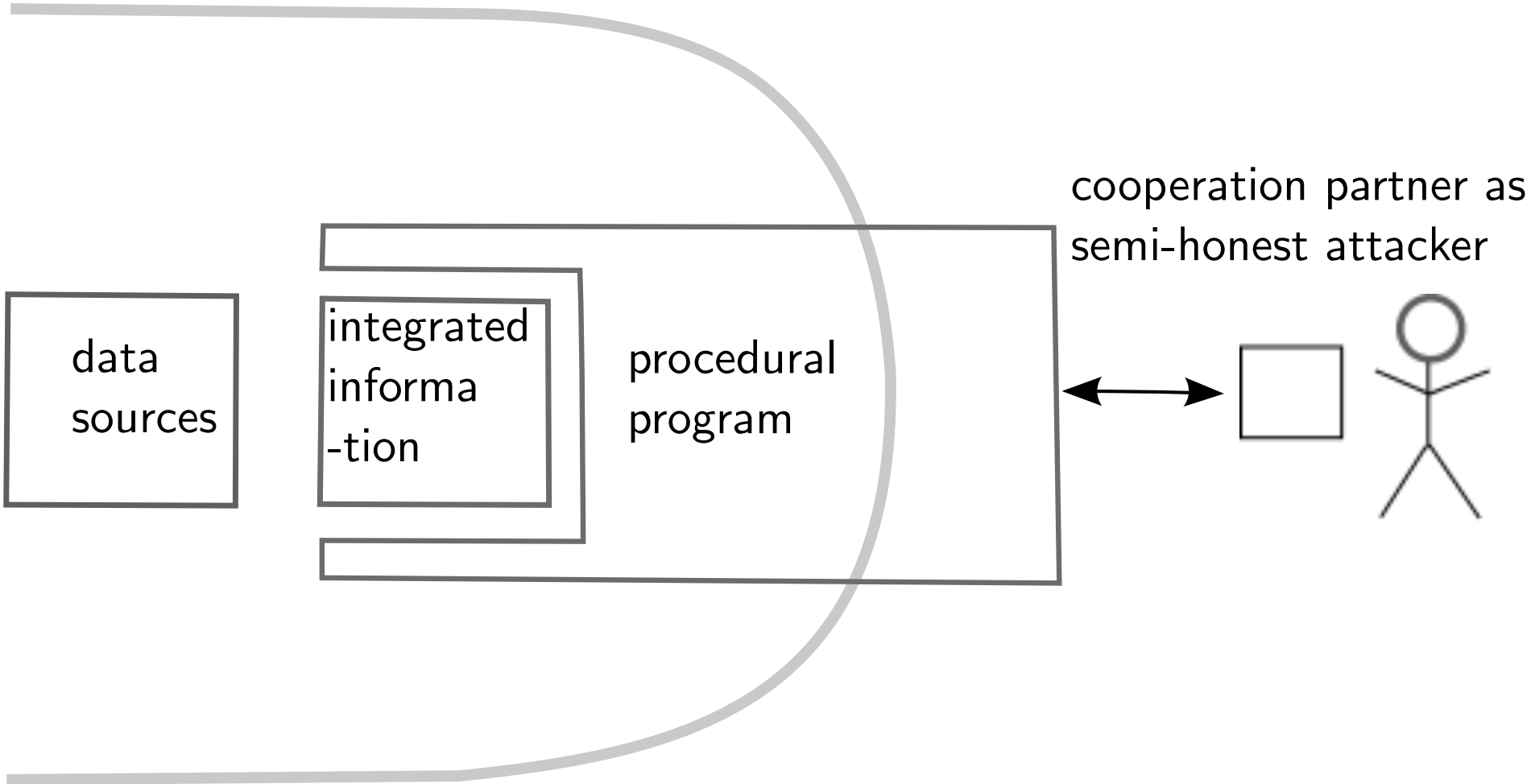
- Logic-oriented belief forming
- Adversarial reasoning
- Information system integration and mediation
- Logic-based inference control
- Language-based information flow control and declassification

Talk Based on

- Joachim Biskup, Cornelia Tadros:
  Constructing Inference-Proof Belief Mediators.
  Published in Data and Applications Security and Privacy, 2015.
- Joachim Biskup, Cornelia Tadros:
  Confidentiality Enforcement by Hybrid Control of Flows
  from Abstract Information States
  through Program Execution via Declassification.

Overview

Inference-Proof Information Mediator



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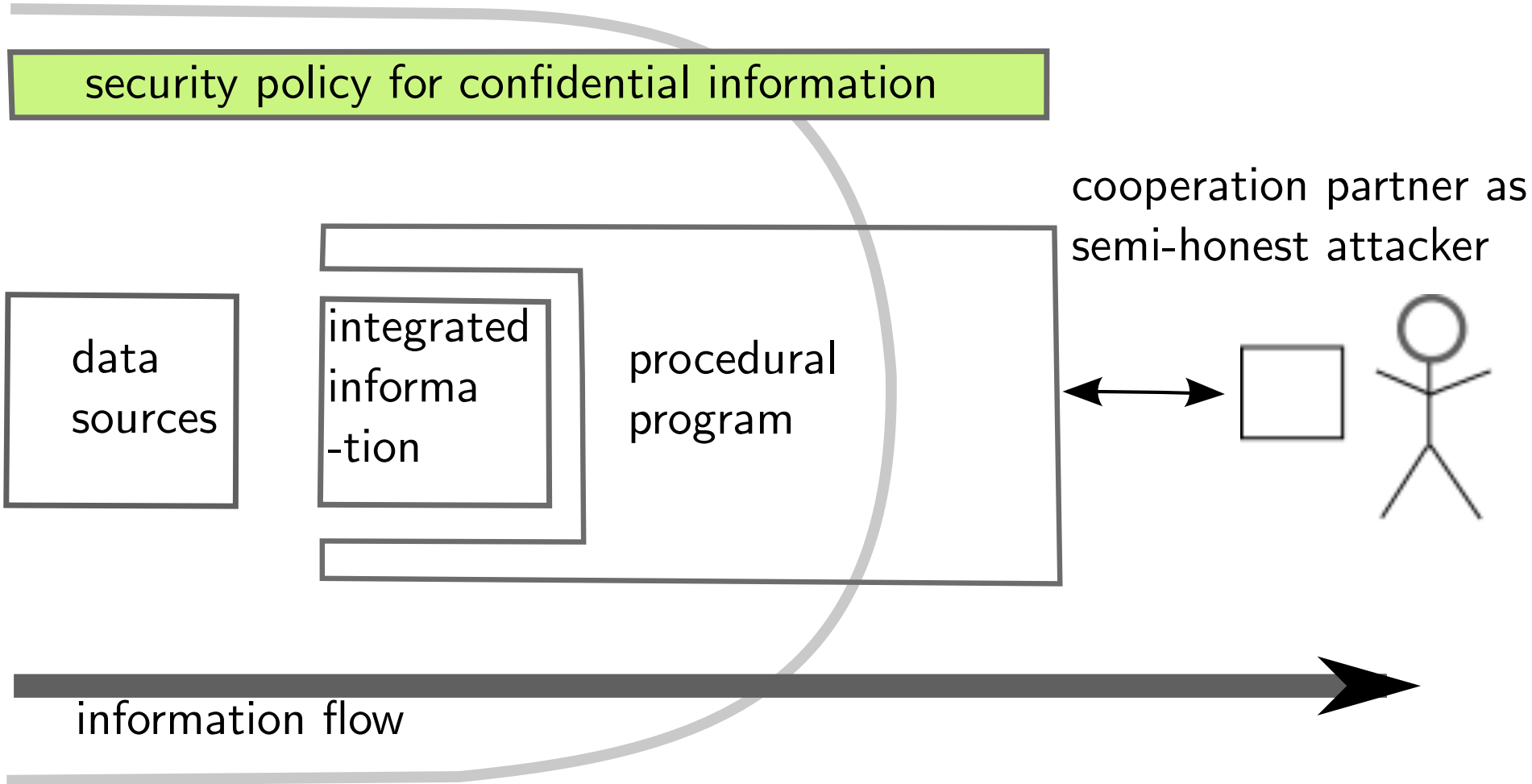

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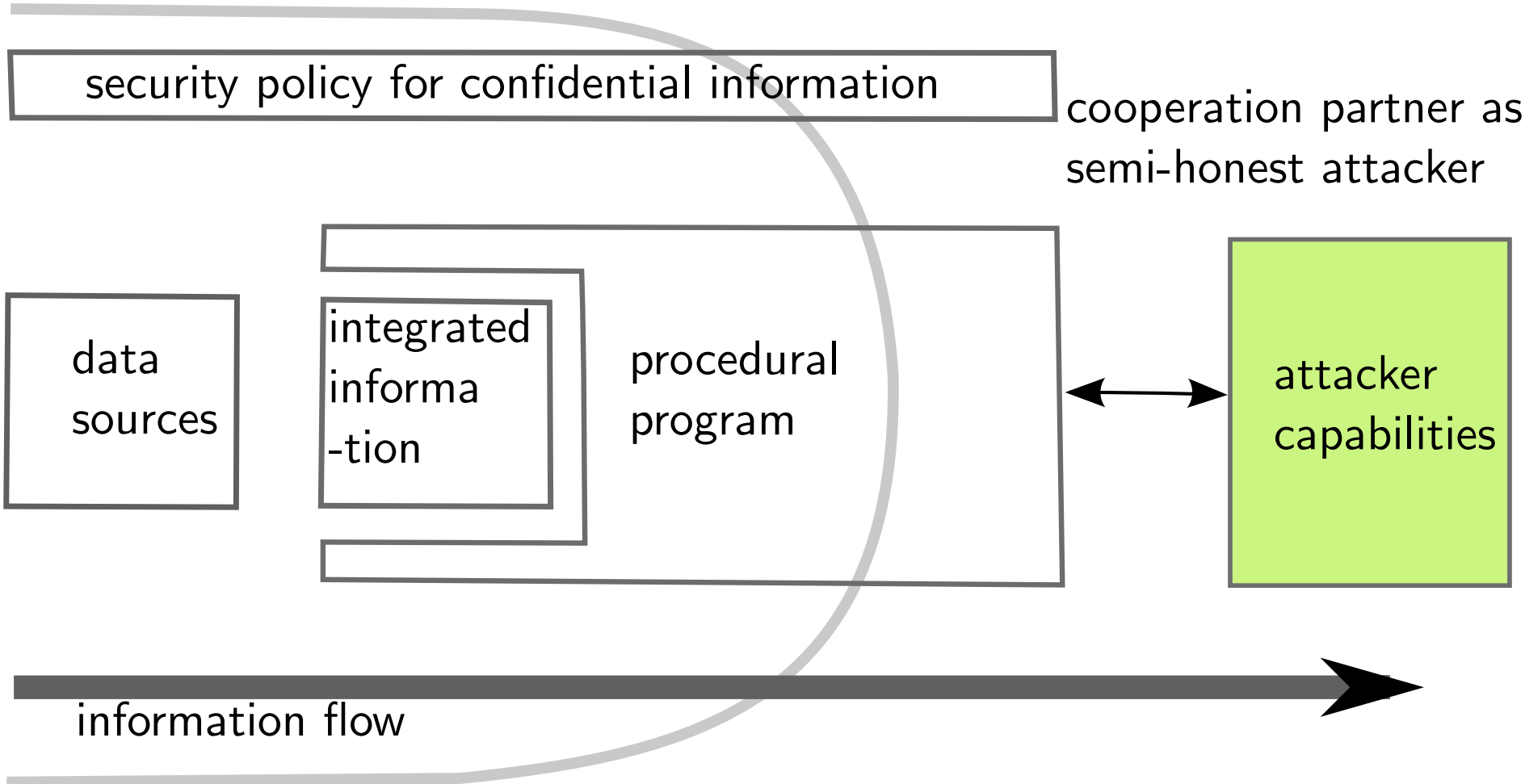

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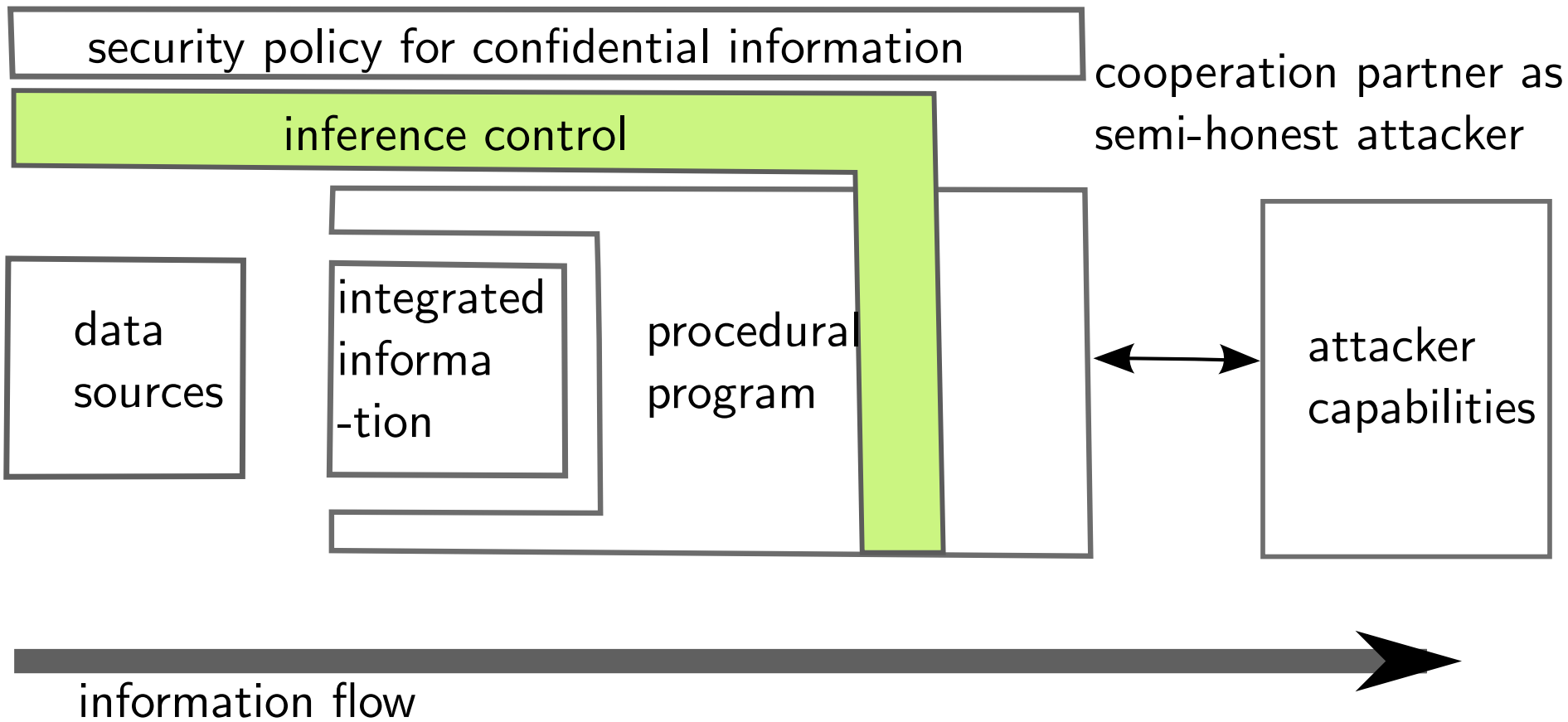
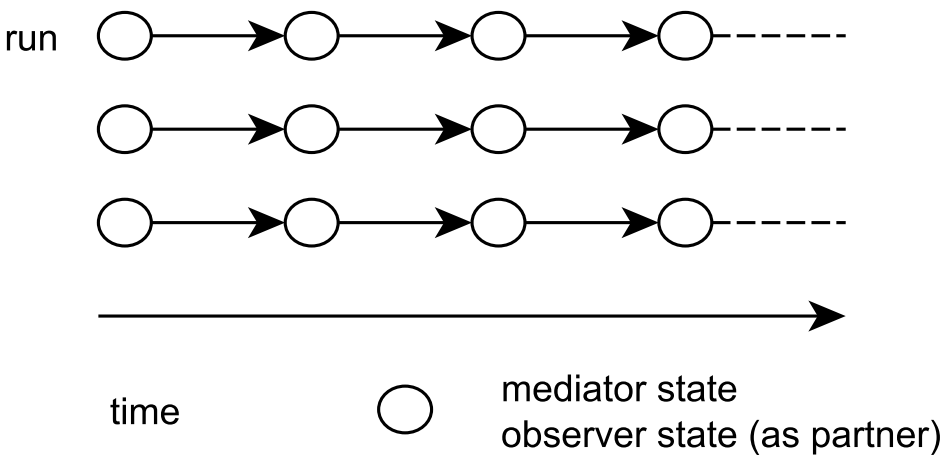


Main Requirements for the Mediator's Construction

- Confidentiality Policy:
  confidential pieces of information
  as sets $\mathcal{S}$ of abstract integrated information states
- Semantics:
  if actual integrated information state *ibs*
  is contained in such an $\mathcal{S}$,
  the cooperation partner must not know this
- Narrower Scenario
  according to assumptions

Semantics of the Confidentiality Policy

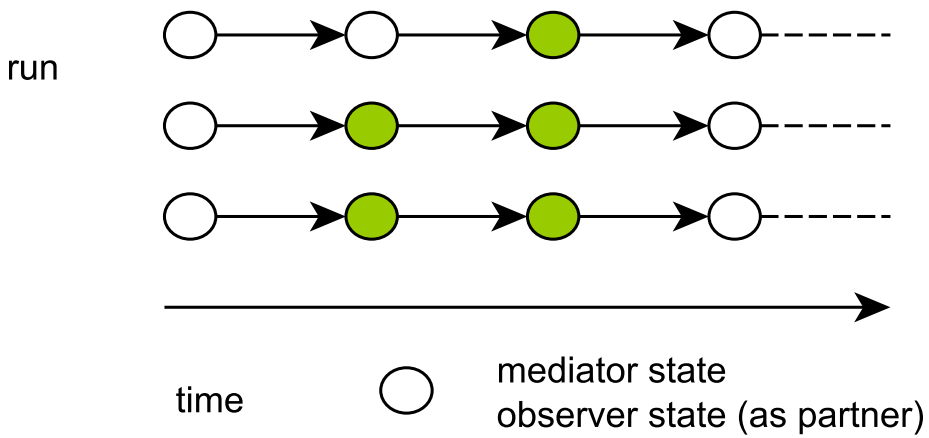
- semantics based on an abstract system model,
  here Runs & Systems



- mediator's functionality
  defined by runs
- observer models partner
  as an attacker,
  a skeptical reasoner

Semantics of the Confidentiality Policy

- policy protects confidential information against skeptical inferences by $\mathcal{K}$

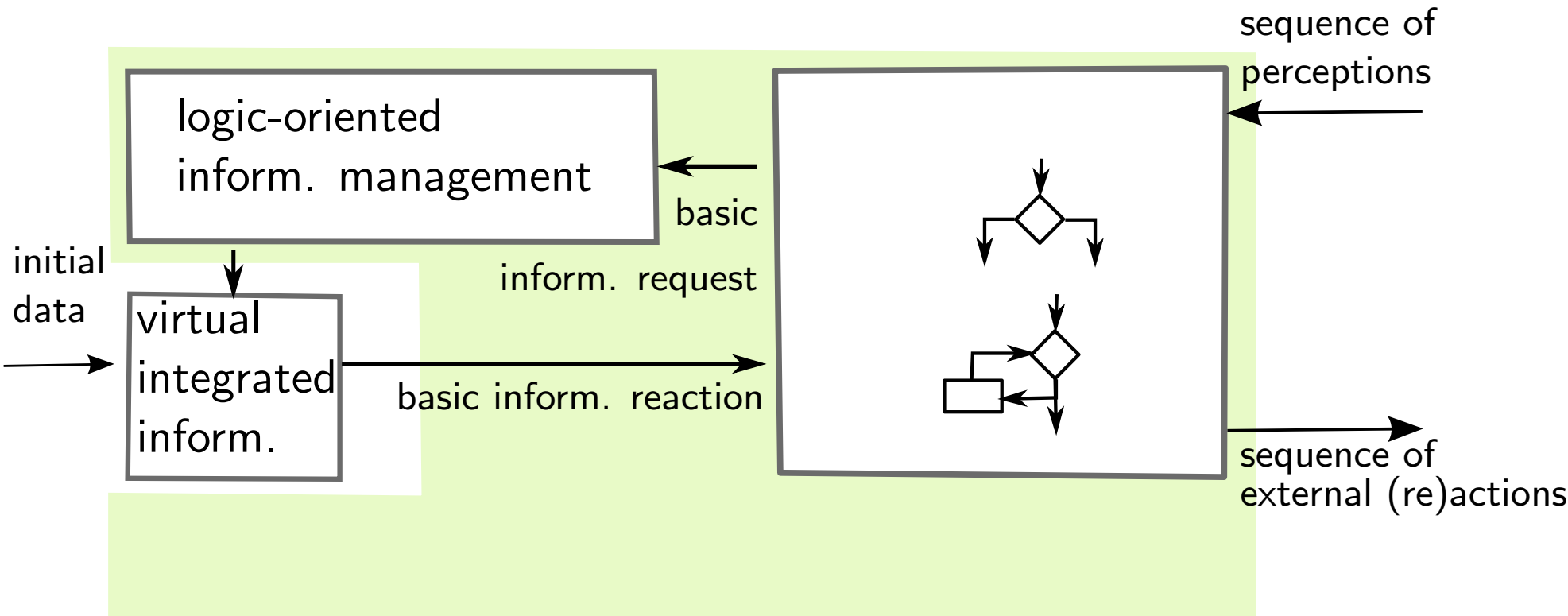


- $\mathcal{K}$ reasons on observations and background
- $\mathcal{K}$ models knowledge as a set of possible situations

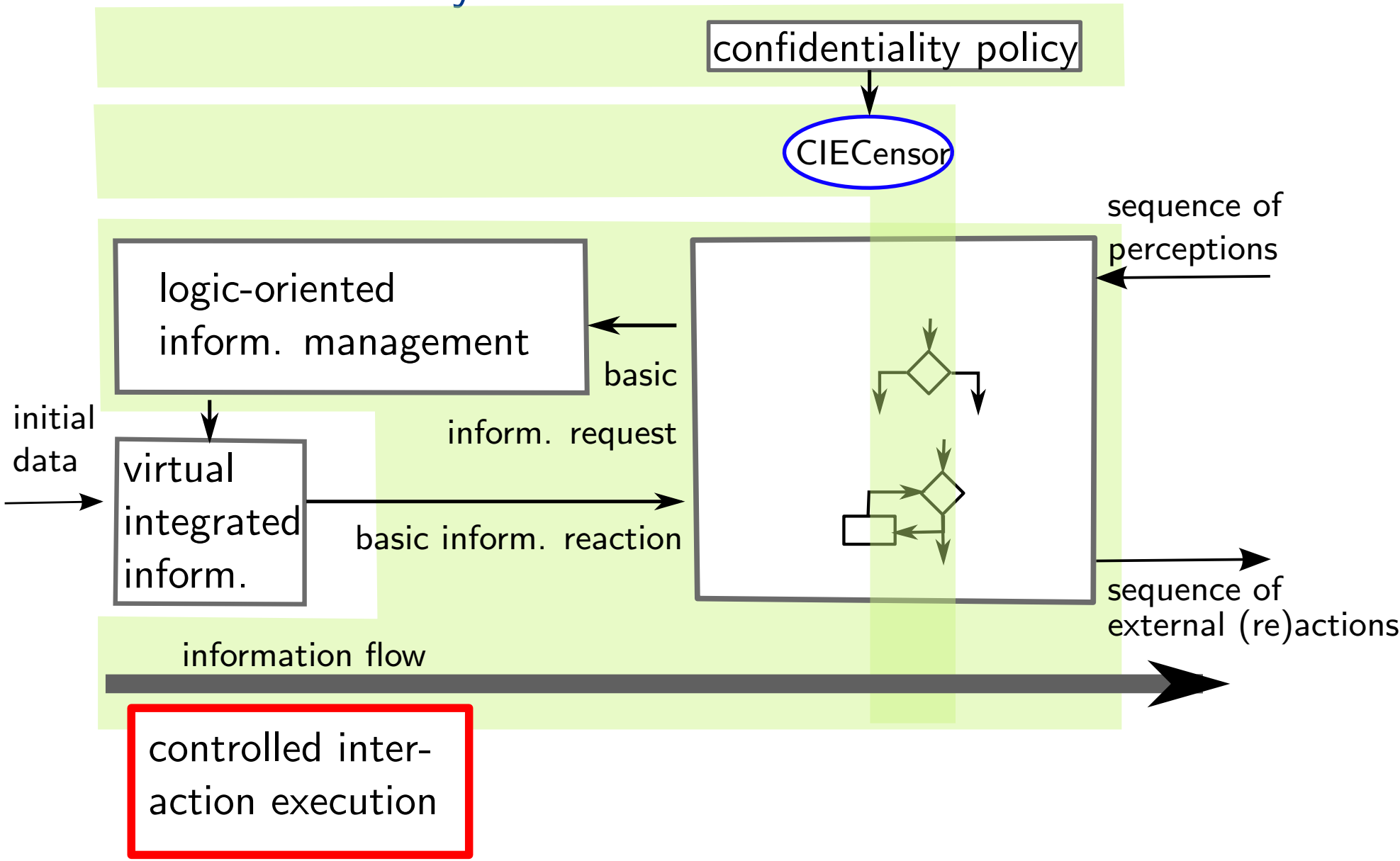
Property (Confidentiality Preservation)

For all runs r and times t and for all $\mathcal{S} \in$ pol it holds $\mathcal{K}(r,t) \not\subseteq \mathcal{S}$.

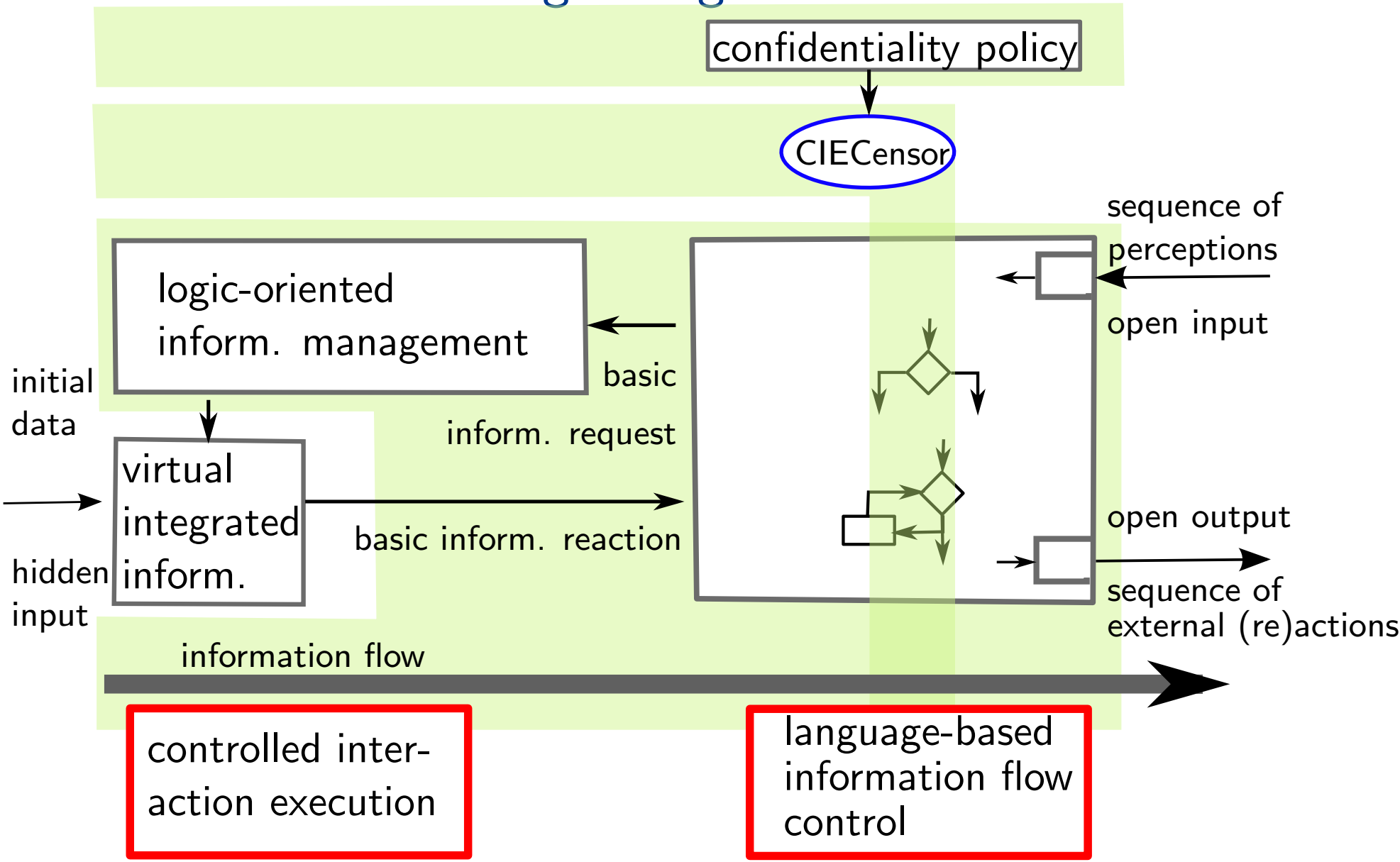
Basic Information Requests on Virtually Integrated Information



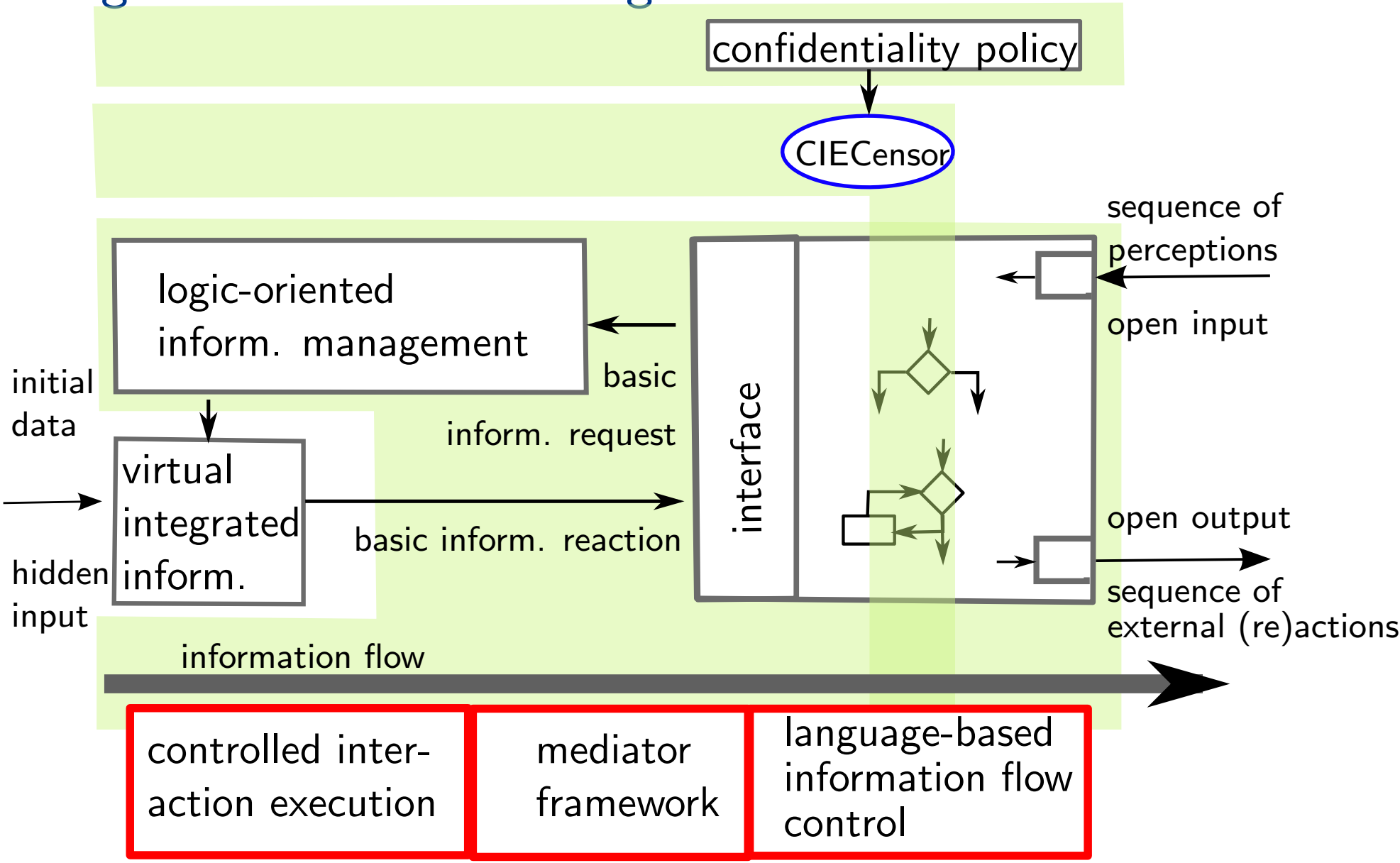
Inference Control by Means of a CIE Censor



Information Flow through Program Execution



Integrated-Information-Program Interface for the Mediator



Mediator Framework for Unified Inference Control

1. Isolation by typing

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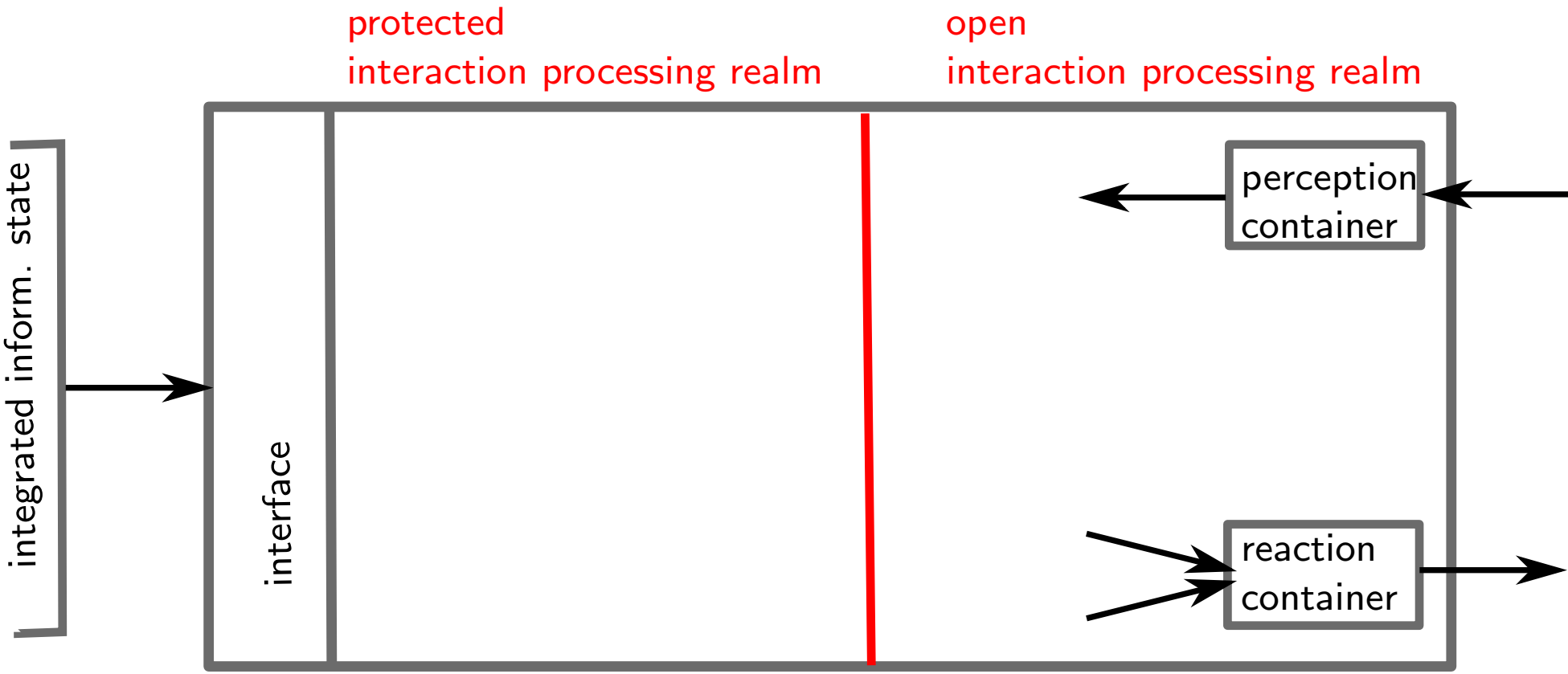
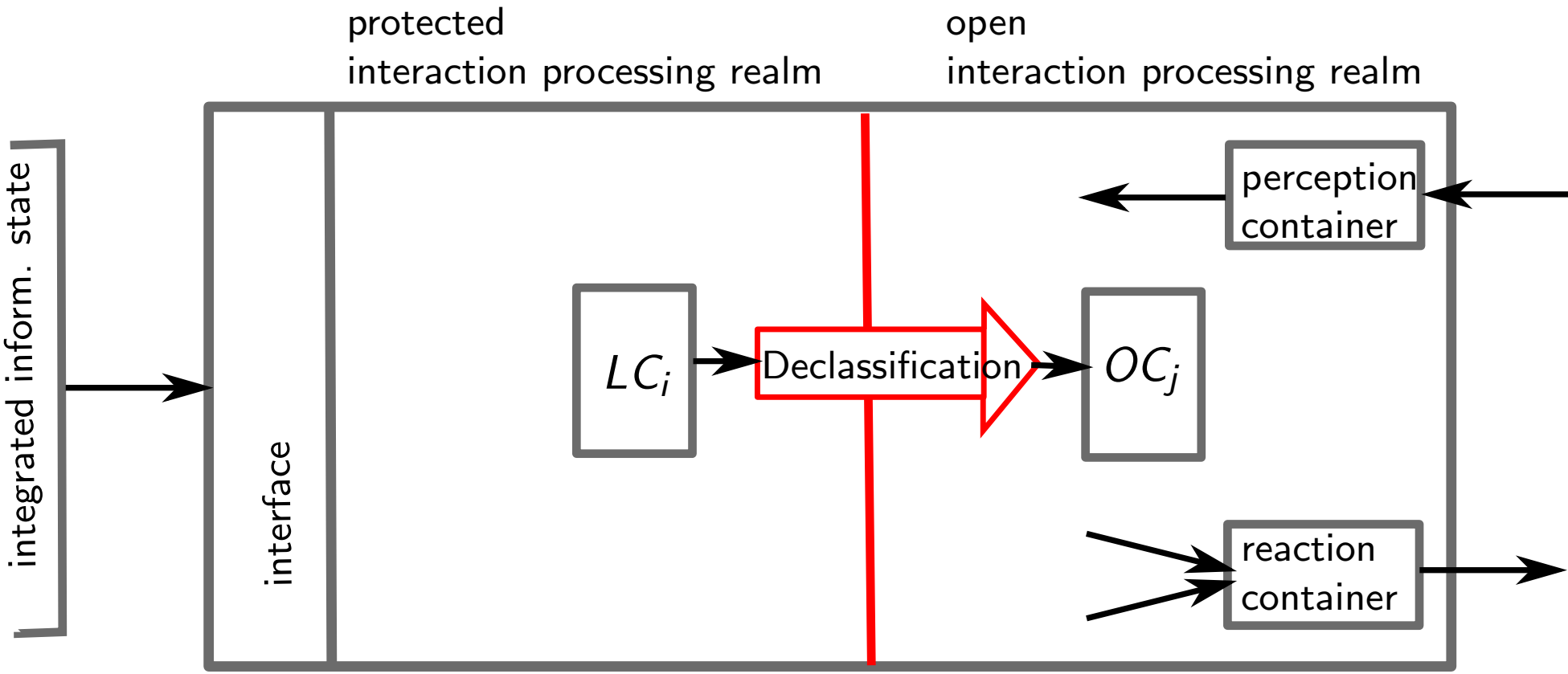
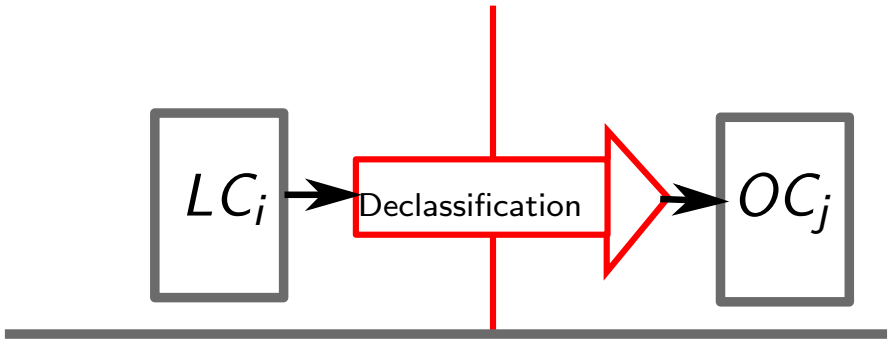


2. Declassification

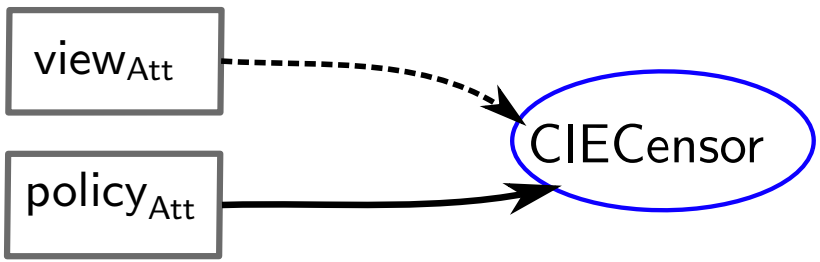


- the placement of declassification assignments is a policy for information provision
- it mainly trades off ressource efficiency for information provision or vice versa

3. History-aware policy compliance



- Policy: sets $\mathcal{S} \subseteq \mathcal{IBS}$ of integrated inform. states



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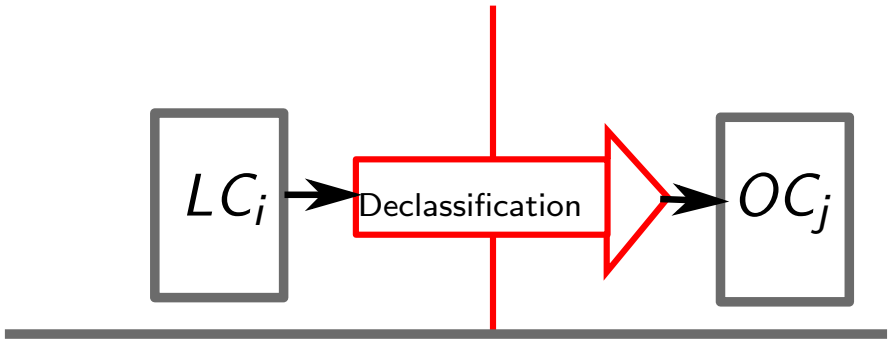

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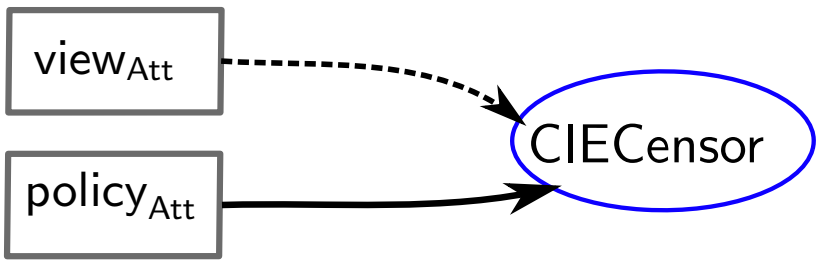

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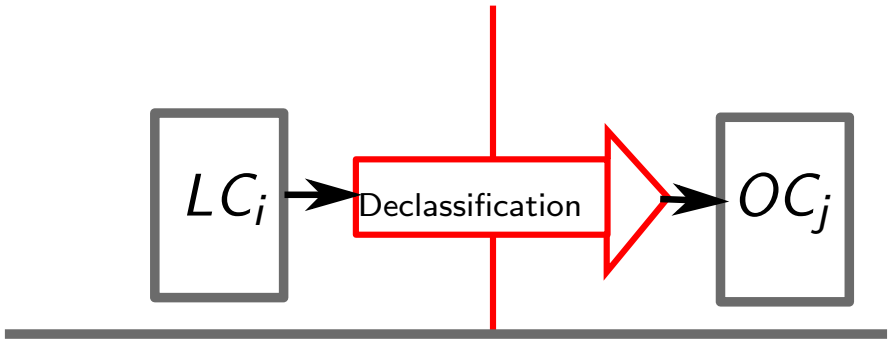

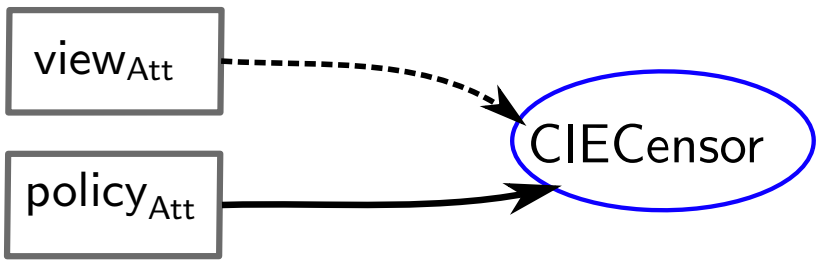

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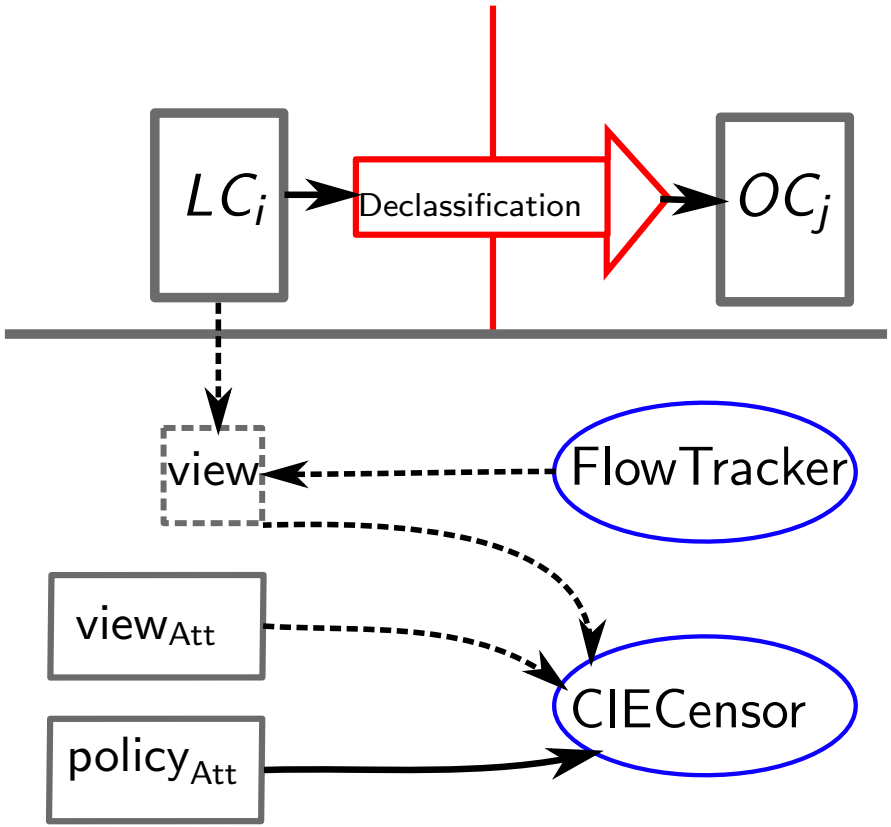
4.Need of Local Flow Tracking



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5. Identifying implicit flows

Goal

Find alternative execution paths

to hide execution paths

originating from confidential pieces of integrated information

by making them indistinguishable from the alternatives

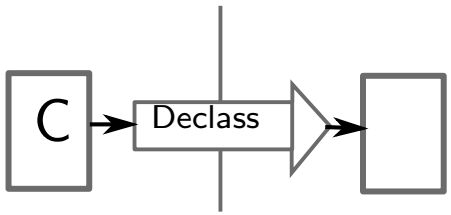
Approach

Identify and represent such candidates of alternative paths

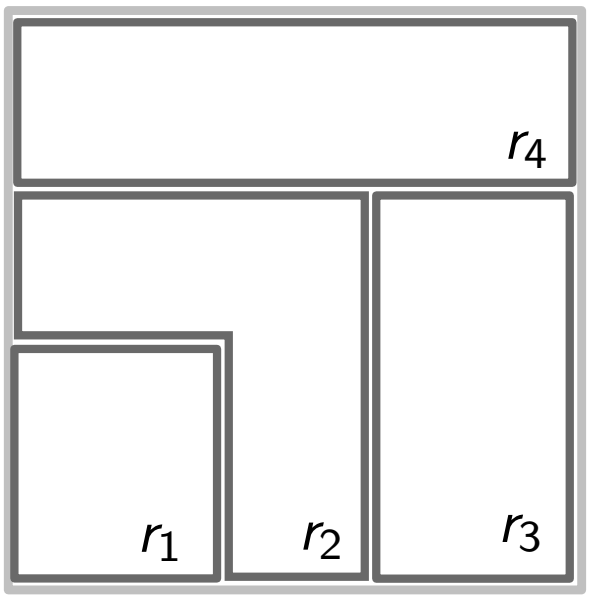
by symbolic execution of protected realm commands

during program execution

6. Determining local flows by FlowTracker

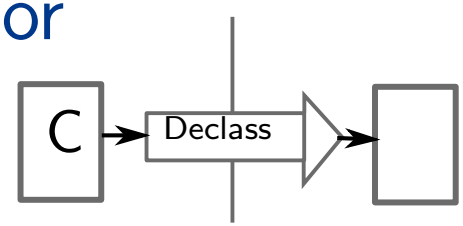


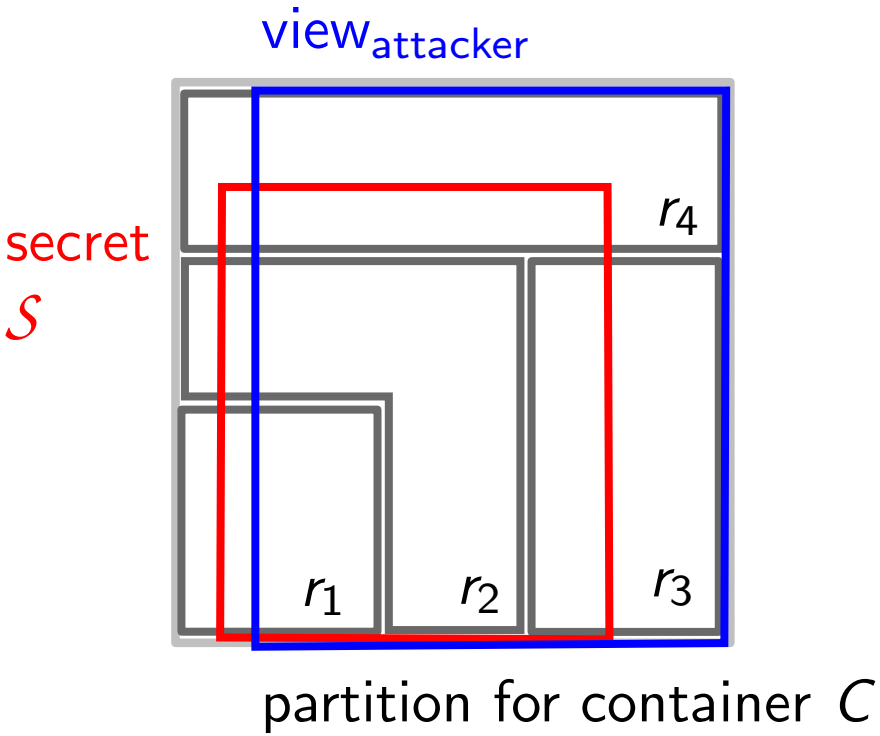
as partition of set of integrated inform. states



- represents indistinguishable execution paths originating from
  the respective inform. states
  leading to a value r_i of a container c
- initialized for basic inform. reactions
- refined by FlowTracker using
  a precomputed symbolic expression for c

7. Evaluation of harmlessness by CIECensor





partition for container C

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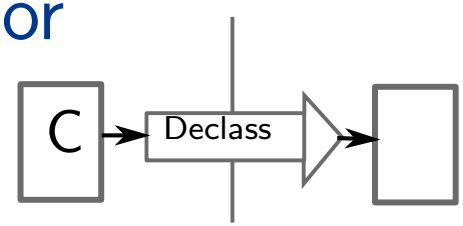
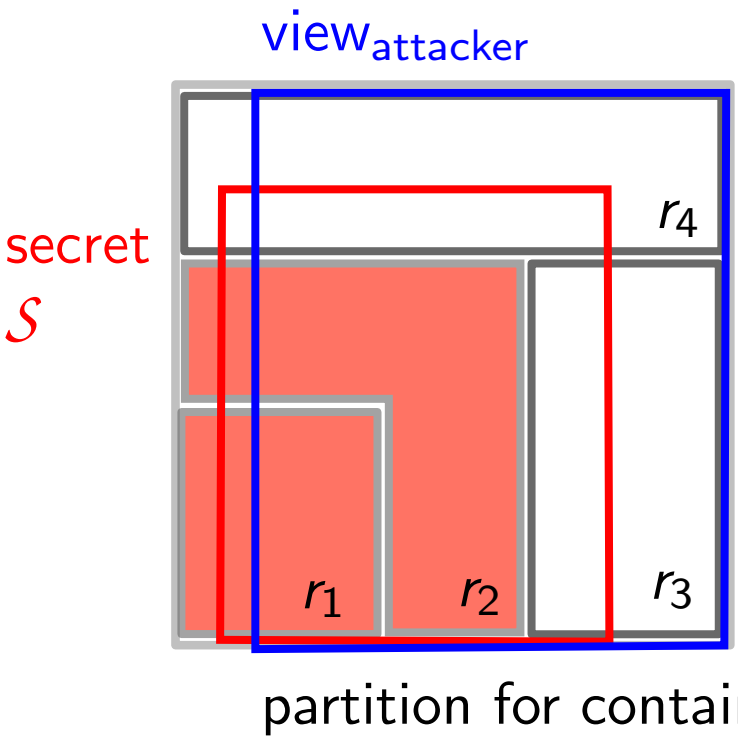


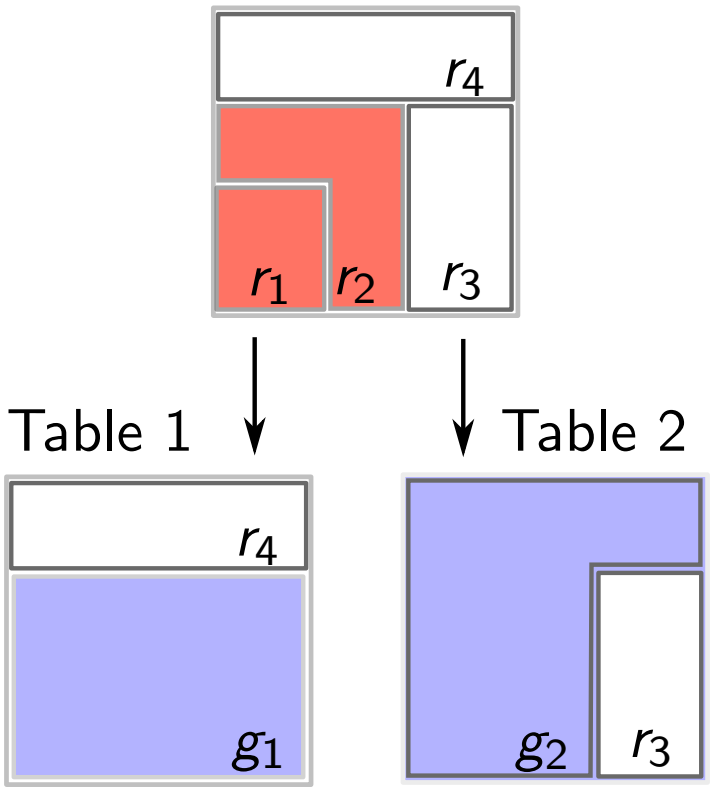


identifying

harmful unions of blocks

$(B_{r_1} \cup B_{r_2}) \cap \text{view}_{\text{attacker}} \subseteq \mathcal{S}$

8. Filtering and modifying by generalization



using a distortion table:

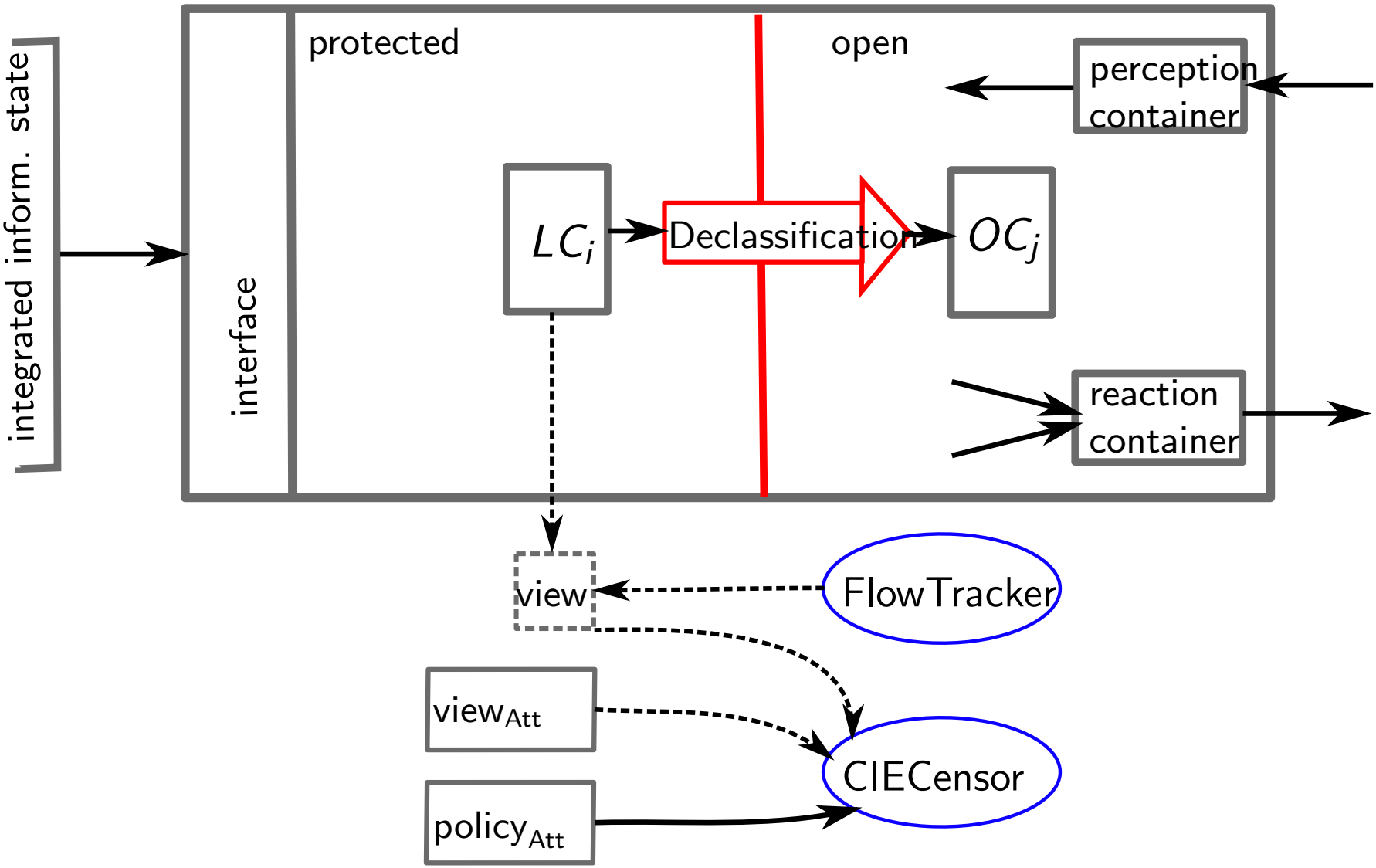
set of indices per harmful union of blocks

$\times$

value

$\rightarrow$ value/generalized value

The Complete Framework



Conclusion

Design, Formalization and Verification of a Mediator Framework

- for a holistic control based on a unified view on heterogenous sources by virtual integration

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