When Data, Processes, and Knowledge Meet Together

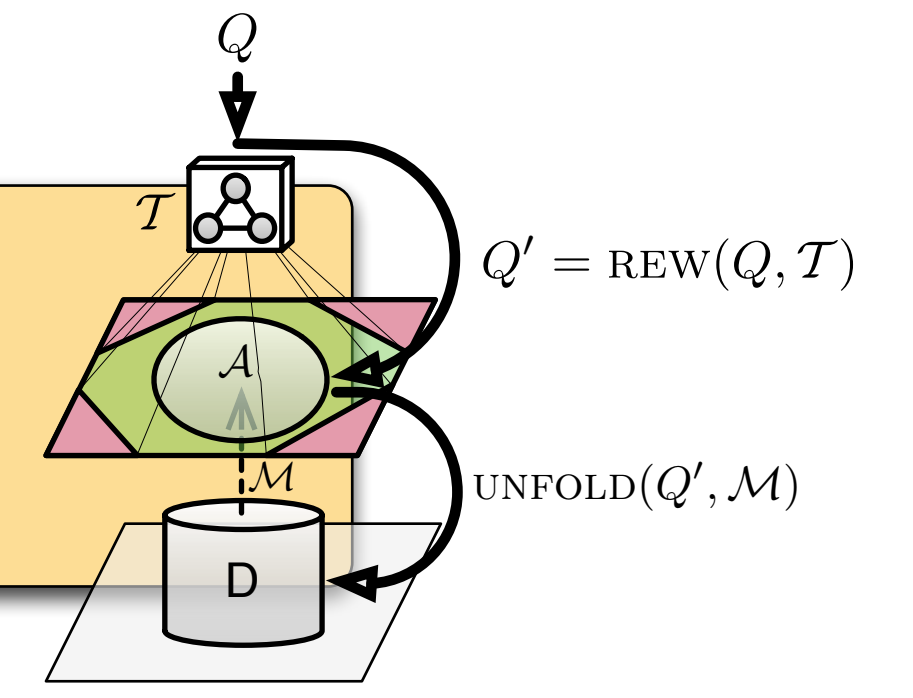**Ario Santoso**
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Our Research

- Investigate the **integration** of **data**, **processes**, and **knowledge** in a unified framework by **combining** the research in:
  - Ontology-Based Data Access **(OBDA)**, and
  - Data-Centric Dynamic Systems **(DCDS)**.

- Our proposal:
  - **Process manipulates** the **data** (**characterizes** the **system evolution**)
  - **Knowledge** component (ontology) is used to
    - **Provide** a **conceptual view** of the overall system based on the domain of interest, and
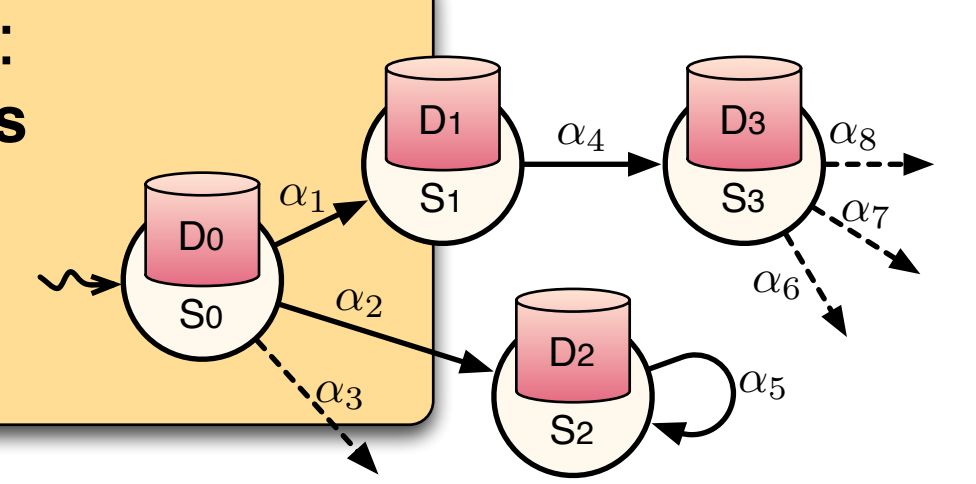   - **Govern** the **system evolution**.

Ontology-Based Data Access (**OBDA**):
- Marrying **data** and **knowledge**.
- Provide a **conceptual view** over **data repositories**.

Data-Centric Dynamic Systems (**DCDSs**):
- A formal **framework** for **business processes specification** and **verification**.
- **Data** and **processes** are treated as first-class citizens.

Semantically-Governed Data-Aware Processes (*SGDAP*) [1]
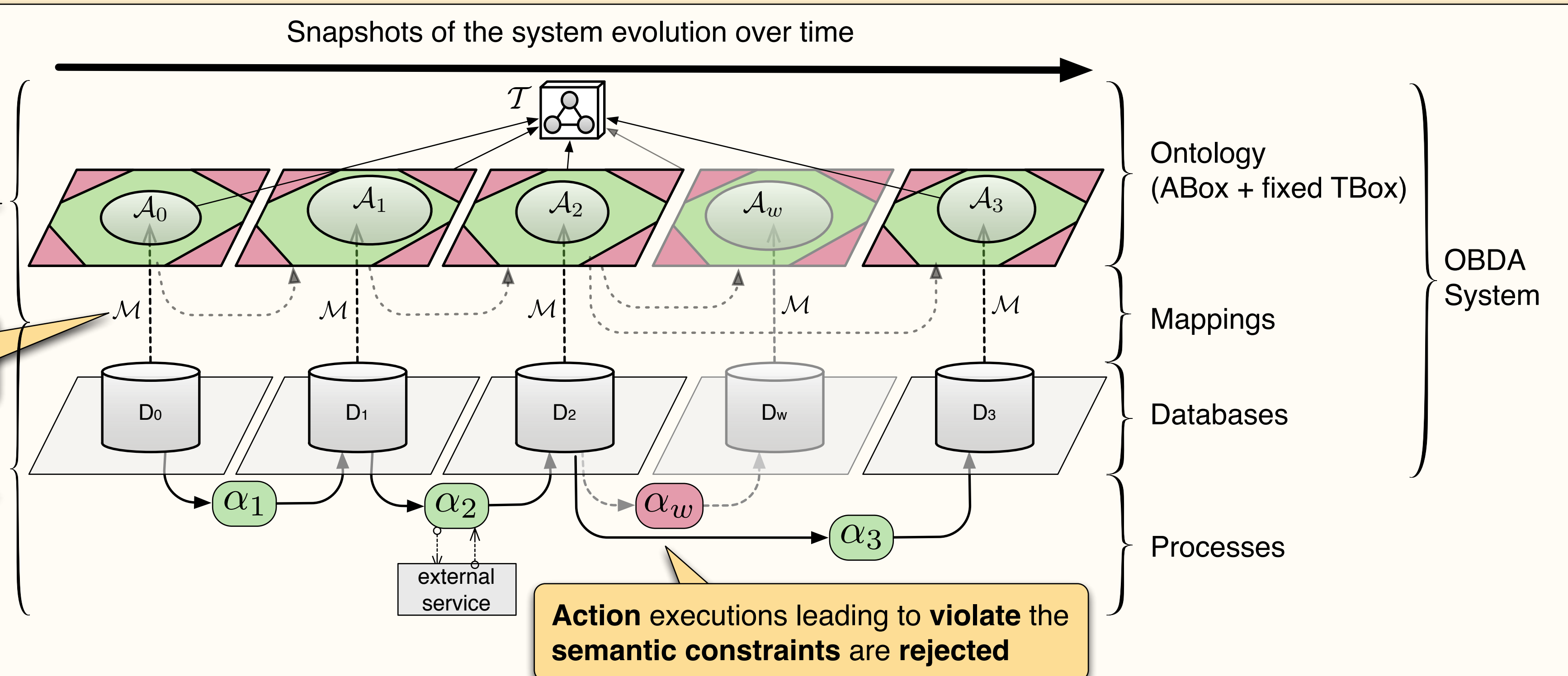
Semantic Governance

Semantic Layer:
- Provides **high level view** of the **system evolution**.
- Captures **Domain of Interest**.
- Regulates:
  - **Change** of **database**.
  - **Process execution**.

Relational Layer:
- **Processes** are **defined** and **executed** in the **relational layer**.
- **Processes** manipulate **Database**.
- **System evolution** occurs in the relational layer.

Mappings define how to obtain ABox from database

Snapshots of the system evolution over time

Action executions leading to **violate** the **semantic constraints** are **rejected**

- Ontology (ABox + fixed TBox)
- Mappings
- Databases
- Processes
- OBDA System

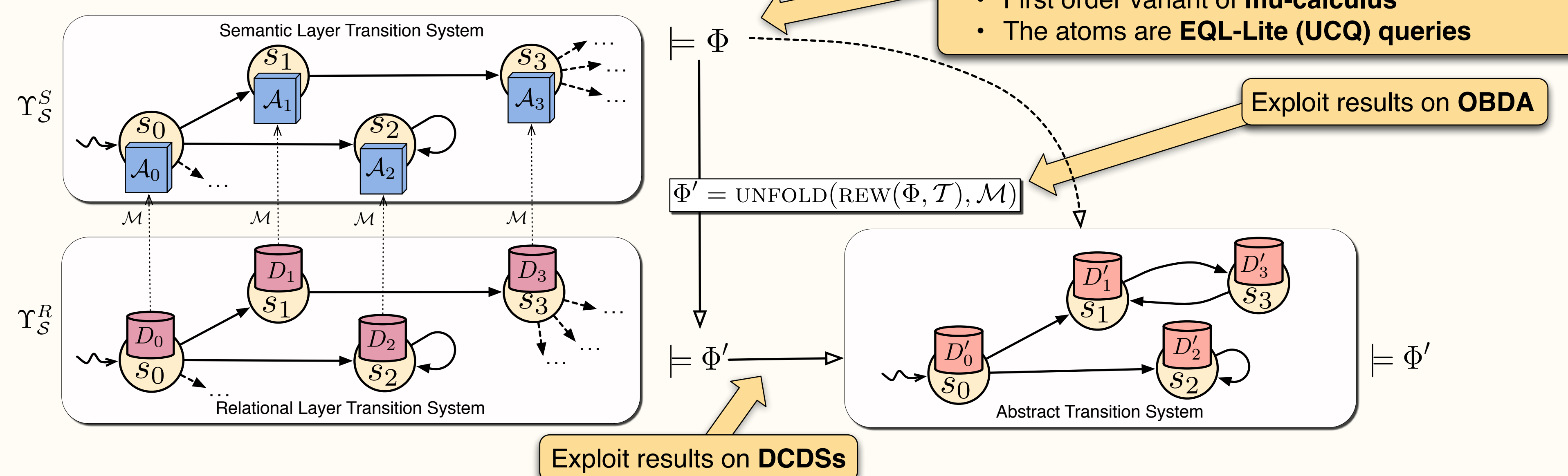### Verification of Dynamic Properties

Dynamic Property:
- **Specified** over the **semantic layer** (at high level)
- First order variant of **mu-calculus**
- The atoms are **EQL-Lite (UCQ)** queries

Exploit results on OBDA

$$\Phi' = \text{UNFOLD}(\text{REW}(\Phi, \mathcal{T}), \mathcal{M})$$

Exploit results on DCDSs

Example of **Dynamic Property**

$$\mu Z.((\forall s.Student(s) \rightarrow Grad(s)) \vee [-]Z)$$
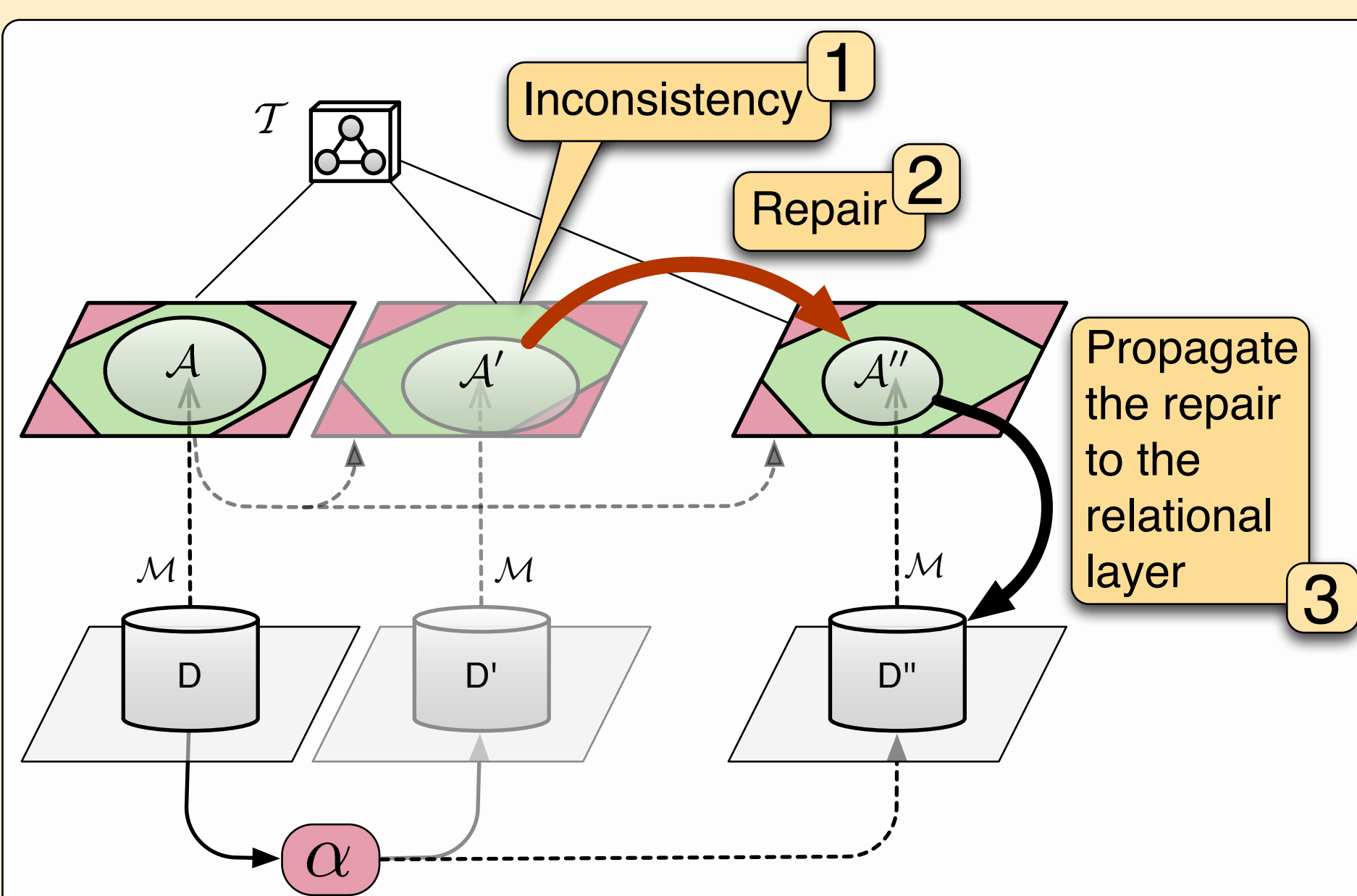
Intuitive meaning:
Every execution leads to a state in which all the students present in that state are graduated
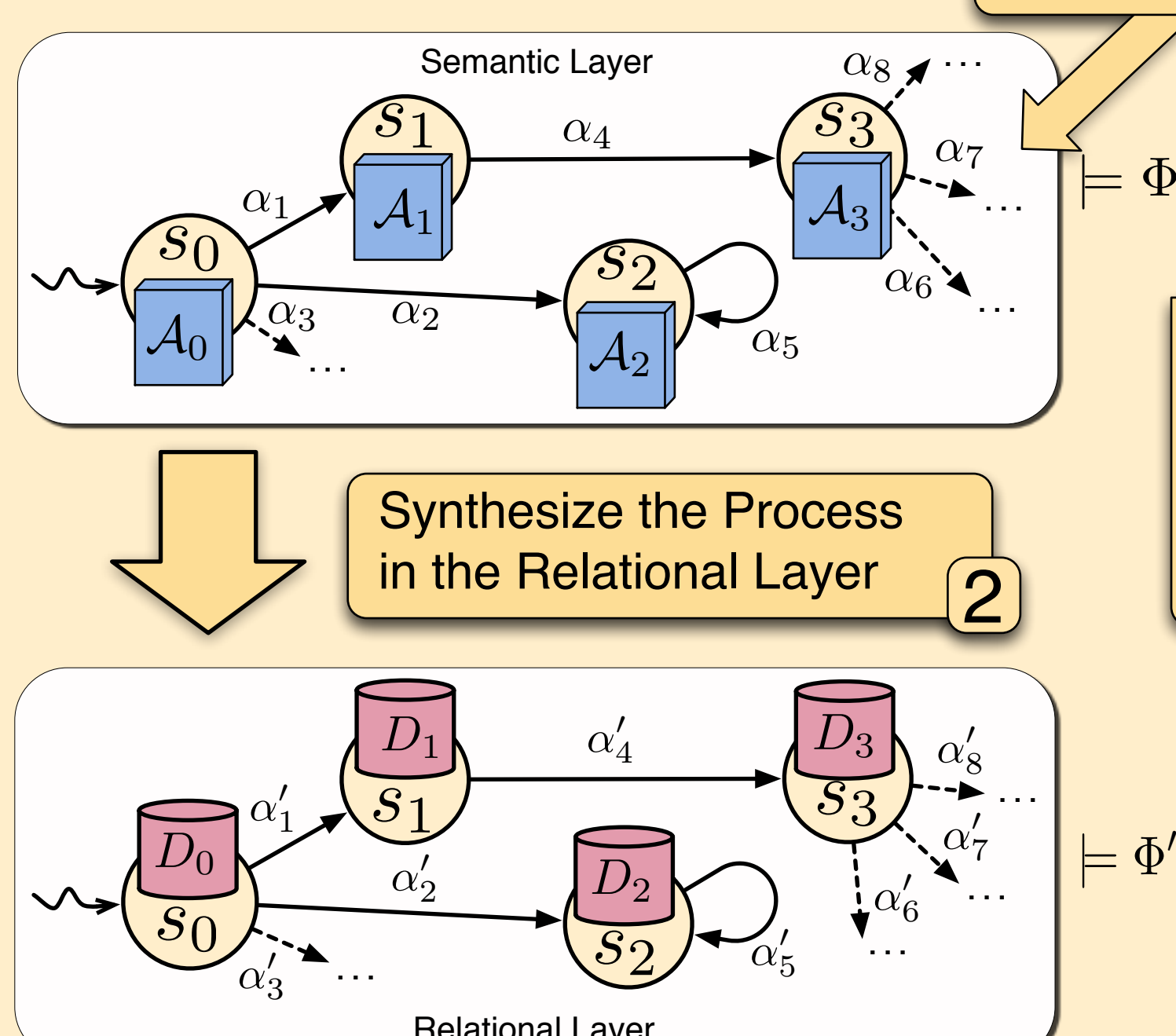
[1] D. Calvanese, G. D. Giacomo, D. Lembo, M. Montali, and A. Santoso. *Ontology-Based Governance of Data-Aware Processes*. In Proc. of the 6th International Conference on Web Reasoning and Rule Systems (RR 12). LNCS, vol. 7497, pp. 25-41 (2012).

What's Next?

Dealing with Inconsistency (Repair-based Semantics)

Inconsistency ①
Repair ②
Propagate the repair to the relational layer ③

Investigate Variation of the Framework

① Process is specified at high level over the semantic layer

Synthesize the Process in the Relational Layer ②

Process Synthesis Problem

Other Research Directions . . .

- *Accommodating updates over the semantic layer*
  - E.g., when a new process is introduced.

- *Quantitative property specification.*
  - **Verification** and **synthesis** in the presence of **quantitative requirements.**

- *High level specification compliance.*

- *Petri Nets for data-aware process formalism.*
  - **Verification** of temporal properties over data-aware processes that are formalized using Petri Nets.

- *Fine-grained analysis of **computational complexity**.*

- *Taking into account requirements from **real world use cases**.*