Perspectives on Consistency for System and Software Contracts

Romain Pascual

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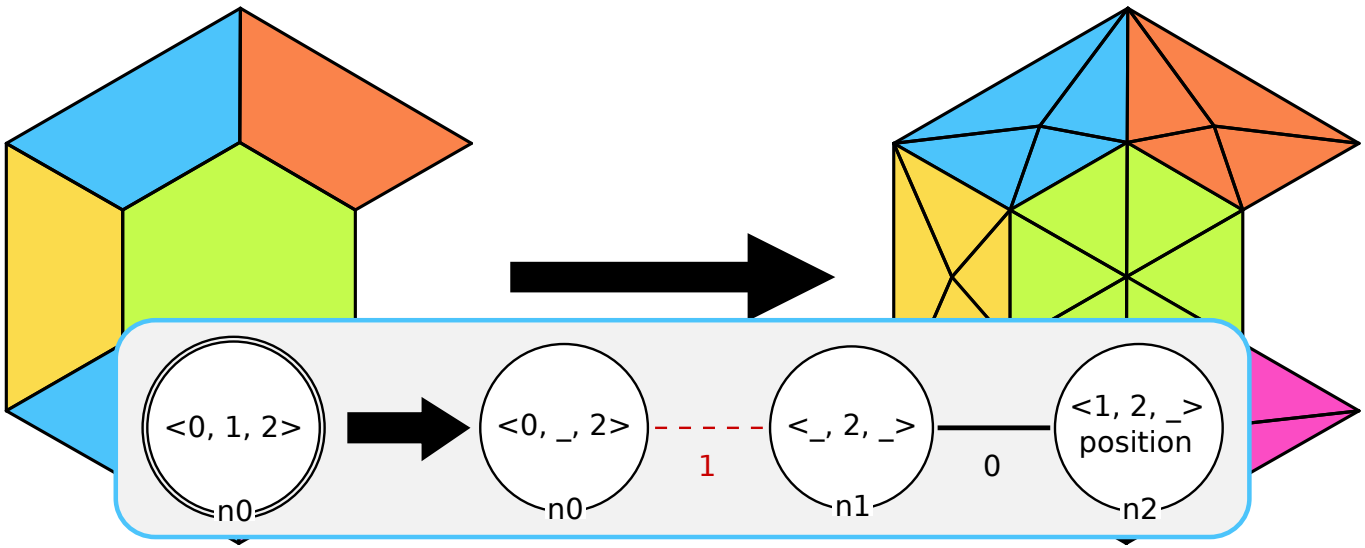
Dagstuhl Seminar 26031

CentraleSupélec | université PARIS-SACLAY

About Me



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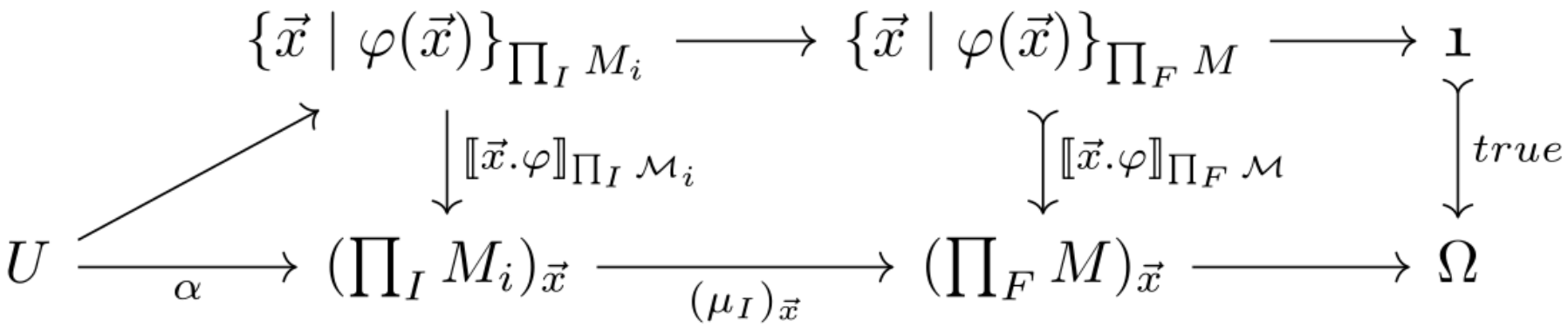
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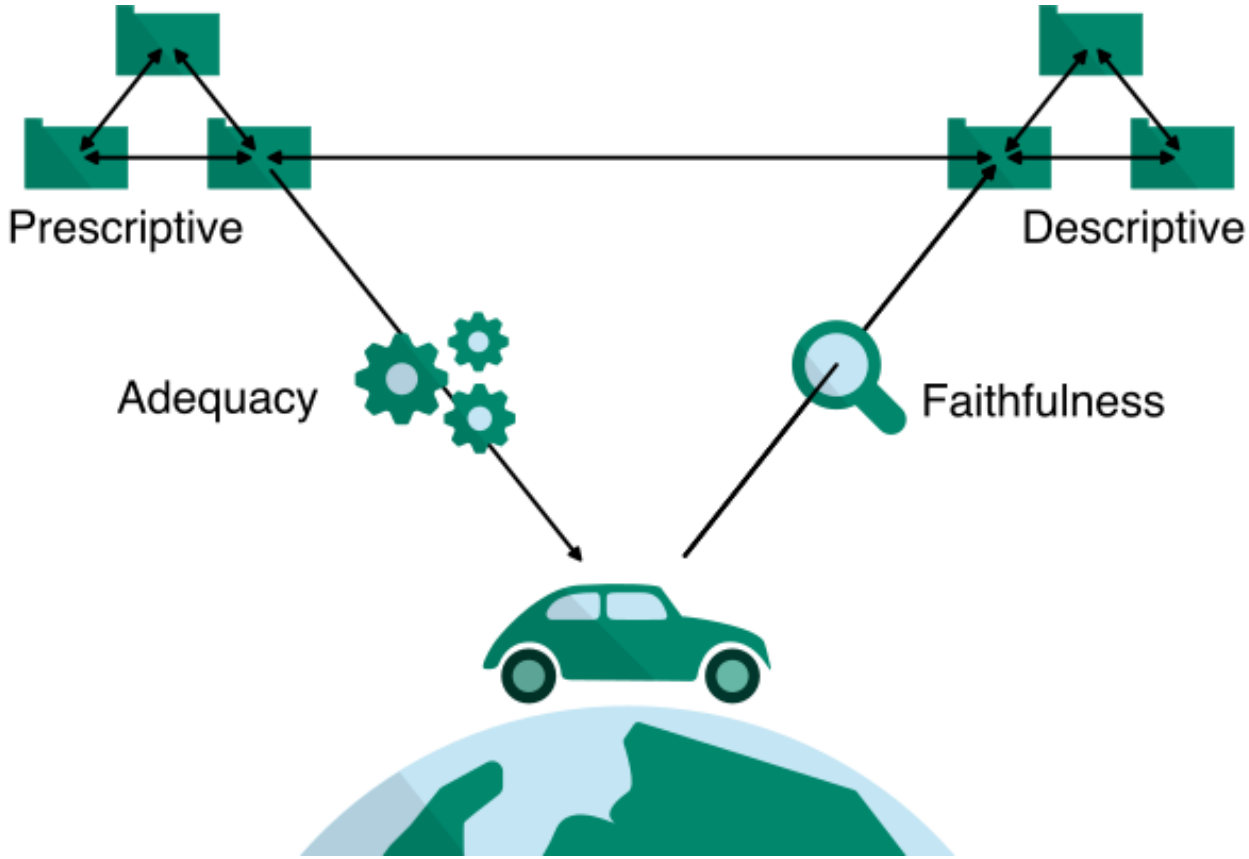


My background alternates between rewriting, semantics, and model consistency: these are my entry points today.

How can system and software contracts be harmonized?

Two Ways to Harmonize

Abstraction

- Unify notions at a higher level
- Single abstract framework
- Risk: losing domain meaning

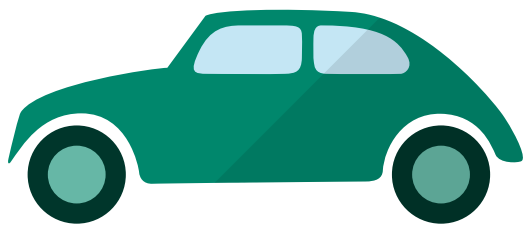
Bridges

- Keep viewpoints distinct
- Identify shared notions
- Enable integration

Consistency appears both in abstraction and in bridges.

Designing Systems with Models

The Example of the Virtual Single Underlying Model methodology



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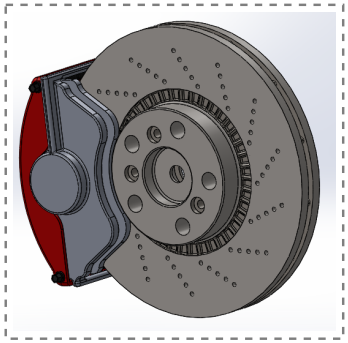
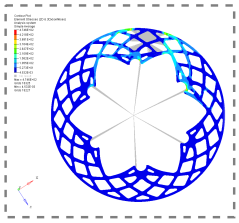
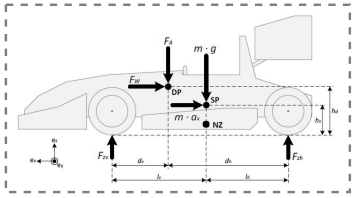


3D Brake Assembly View

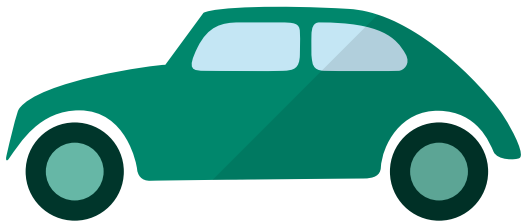


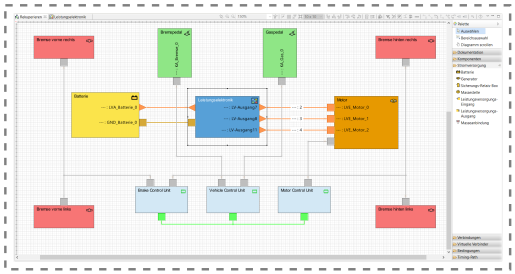
Tribological Simulation View

X-in-the-Loop Test Deployment View

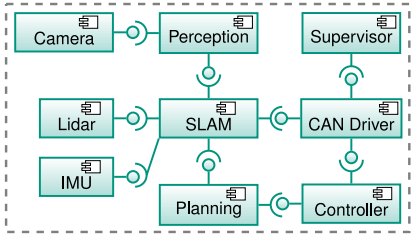


Simplified Vehicle Model View





E/E Topology View (PREEvision)



Autonomous Driving Components View

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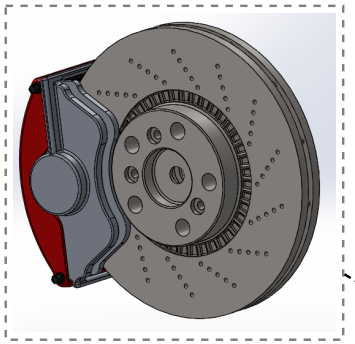

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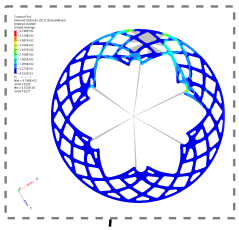

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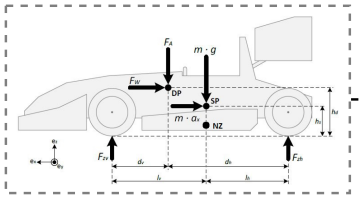

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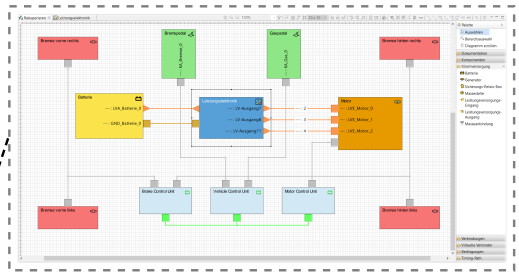

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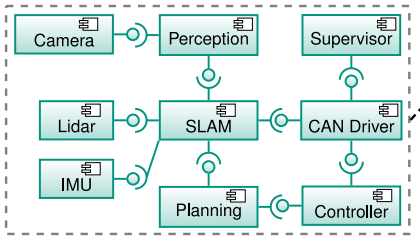

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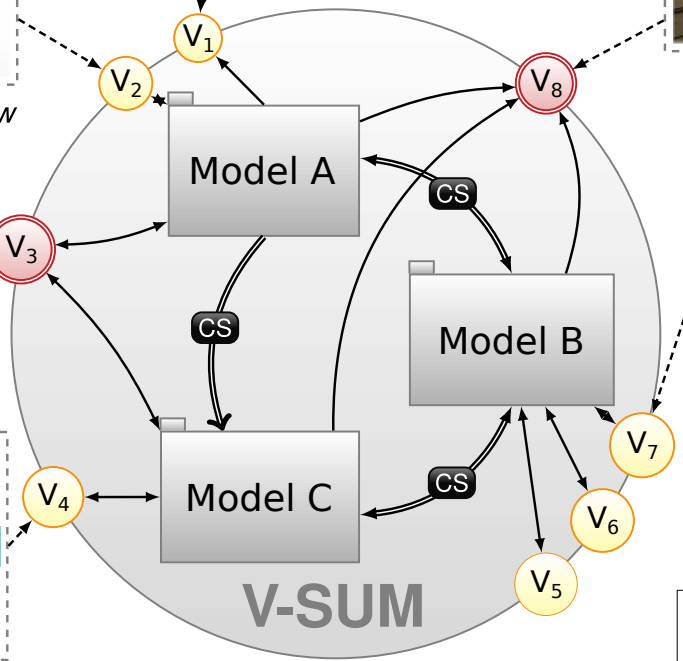

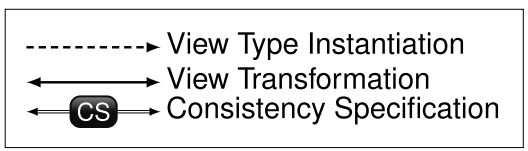

Models, Semantics, Consistency

Model: an abstract representation of an original for a given purpose

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Models

- UML diagrams
- Automata
- Differential equations
- Source code
- Sketches on a napkin

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Semantics

(ex. for Java programs)

- Traces
- Pre/post
- Test outcomes
- Quantitative properties

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Consistency

- "System can be built"
- Preservation by transformations
- Inability to derive falsity (proof-theoretic)
- Existence of models (model-theoretic)

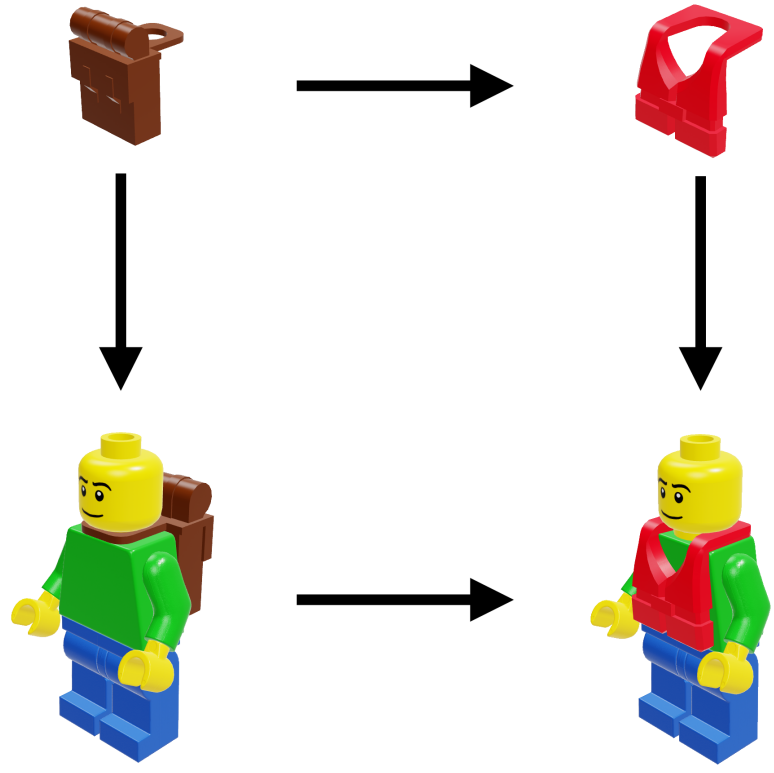
Abstraction

Models	**Semantics**	**Consistency**
$m \in M$	$[\![\cdot]\!] : M \to S$	$\sim \subseteq M \times M$

Abstraction lets us reason about models, semantics, and consistency **without committing** to a specific formalism.

Operations on Models

- How to modify them?



Contracts for Operations on Models

Model repair

$$\{\top\} \qquad (A', B') := \mathsf{repair}(A, B) \quad \{A' \sim B\}$$

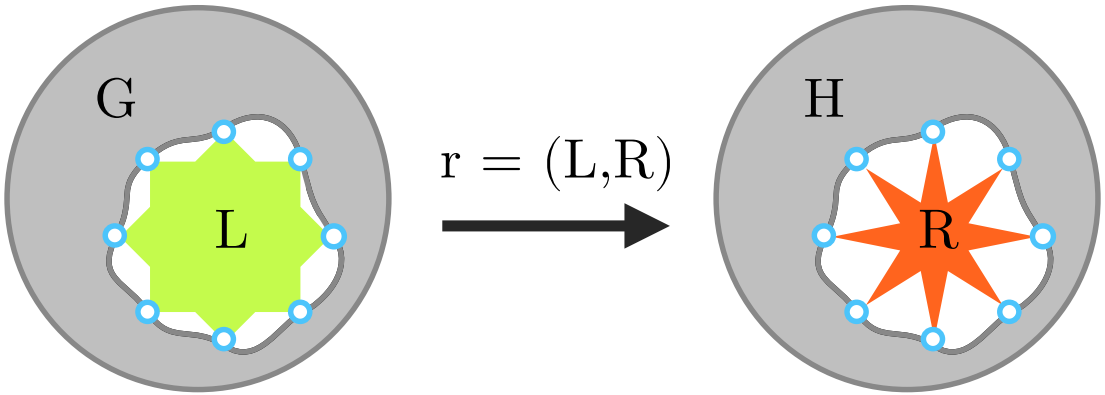
Model slicing

$$\{A \sim B\} \qquad A_s := \mathsf{slice}_B(A) \qquad \{A_s \sim B\}$$

$$\{A \not\sim B\} \qquad A_s := \mathsf{slice}_B(A) \qquad \{A_s \not\sim B\}$$

Operations as Graph Rewriting

Models as graphs $\Rightarrow$ model operations as graph transformations.



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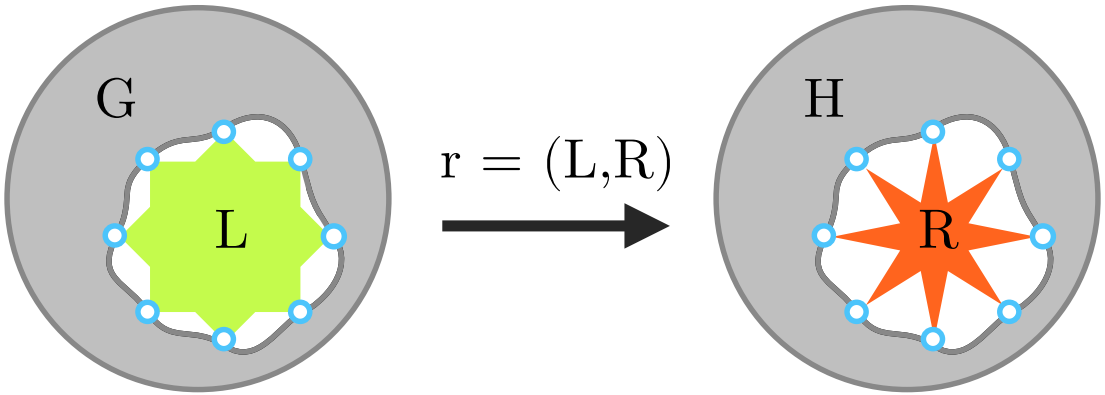


Pre	**Operation**	**Post**
$L \subseteq G$	$L \to R$	$R \subseteq H$

Structural conditions on graphs, not temporal conditions on executions.

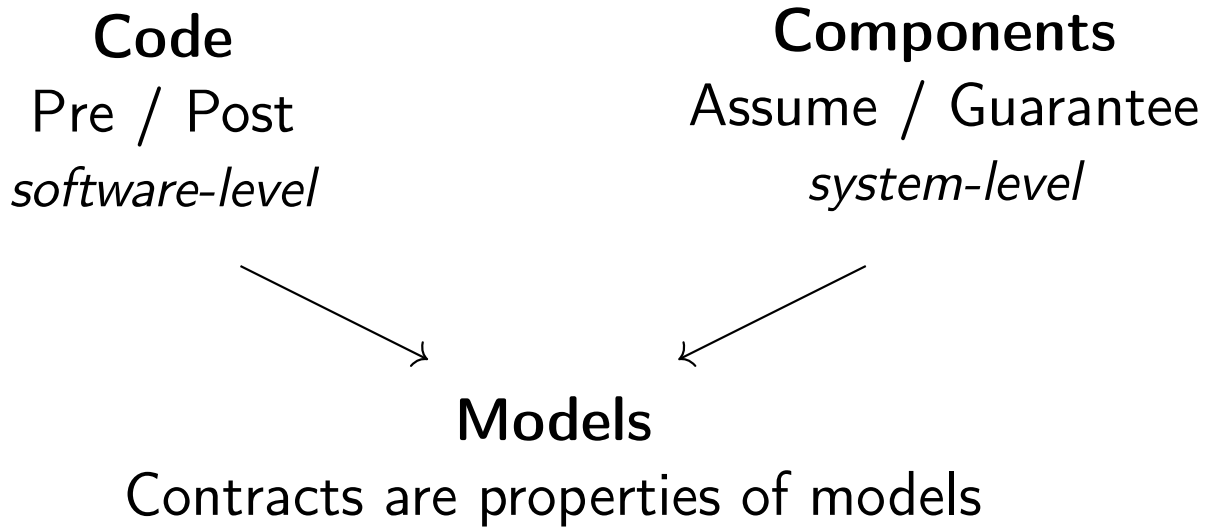
1. Graph rewriting already comes with a **contract-like structure**.
2. Contracts need not be about behavioral properties.

Contracts for Code and Components

Code
Pre / Post
software-level

Components
Assume / Guarantee
system-level

Contracts for Code and Components



Can harmonization happen at the level of the underlying models?

Contracts as Models

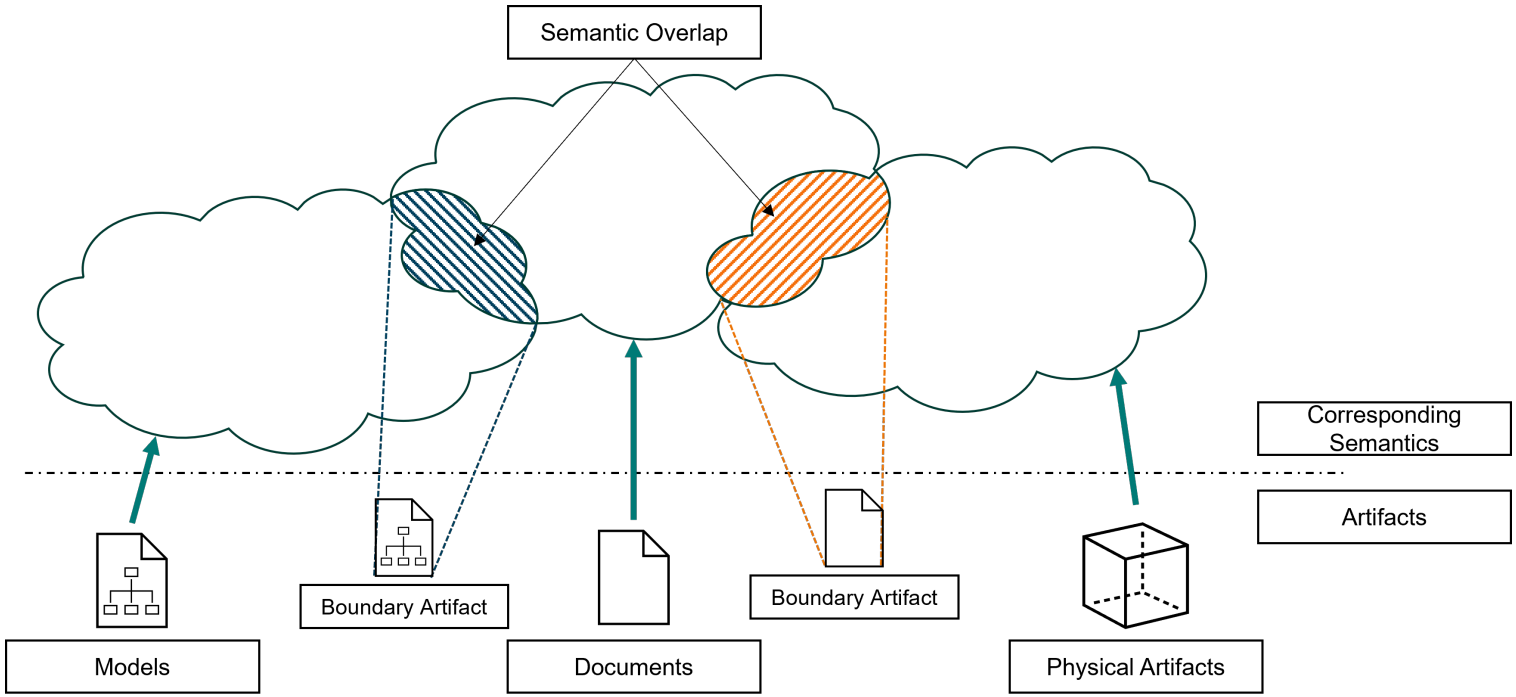
Contracts can be seen as **models** capturing **assumptions** and **guarantees**:

- **Compatibility** of contracts: **joint consistency**.
- **Refinement** of contracts: **preservation of consistency**.

Consistency problem appears whether we call the artifacts **models**, **views**, or **contracts**.

Where Harmonization Becomes Difficult

How to talk to each other?



Different communities talk about the same things with different words.

Harmonization is less about tools, more about agreeing on **properties**.

Open Questions

- Could **consistency** be the right unifying notion to harmonize system and software contracts?
- When are contract inconsistencies design errors – and when are they **useful signals**?
- What should be made **explicit**, and what should remain **implicit**?