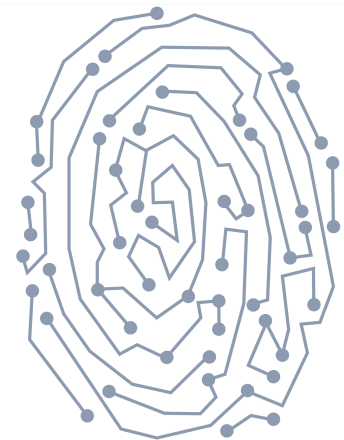


Quantitative Relational Connectors and Heterogeneous Model Checking

Florian Guthmann

2026-09-16



What is this about?

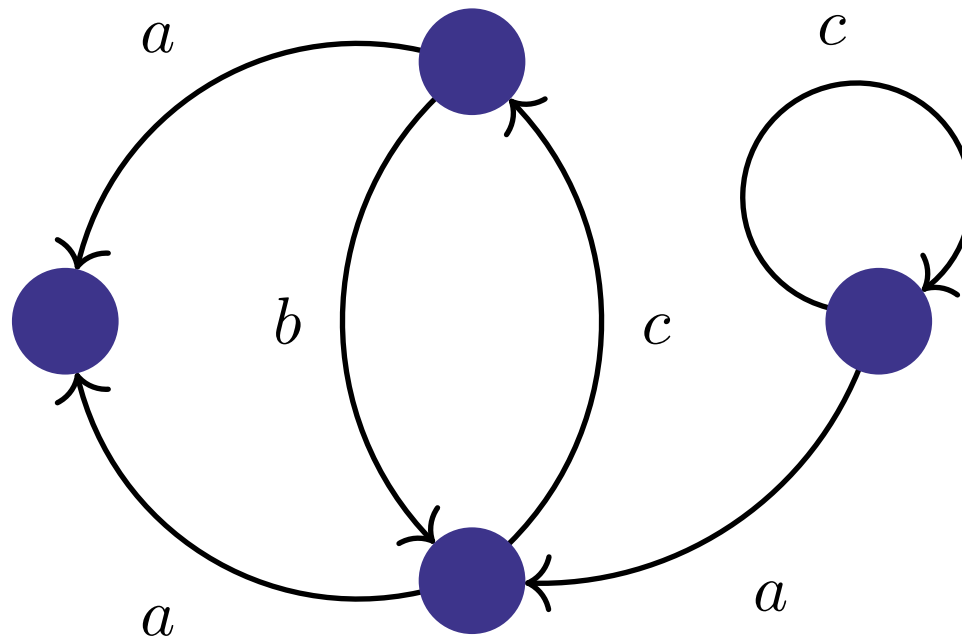
compare state-based systems of different type

Quantitative Relational Connectors

say how far apart they are

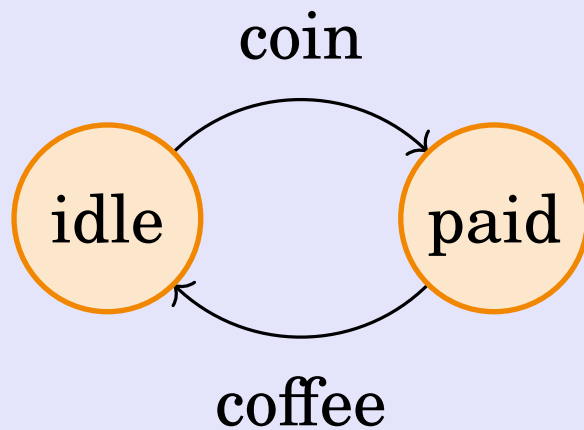
State-based Systems

$\mathcal{P}$ $\mathbb{R}^{(-)}$ $\mathcal{P}(\mathcal{A} \times (-))$

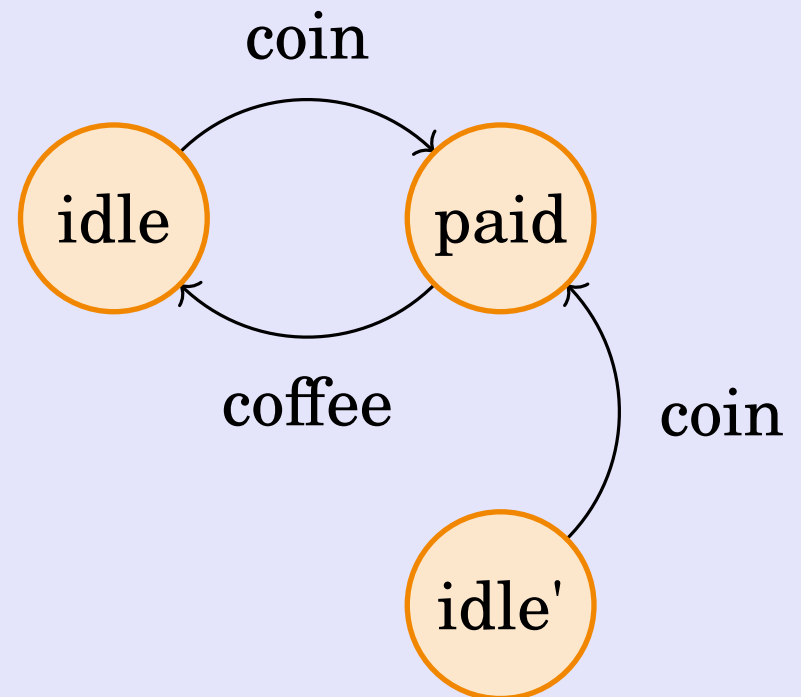


When do states behave the same?

Coffee machine *A*

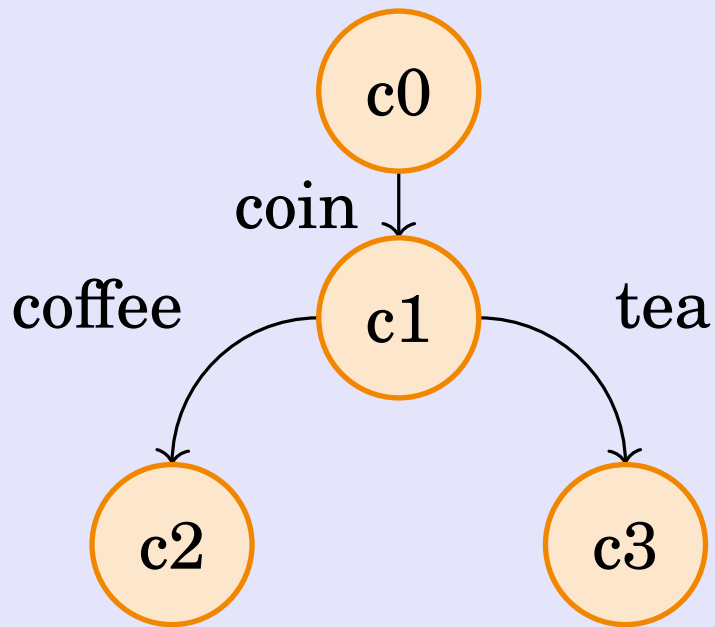


Coffee machine *B*

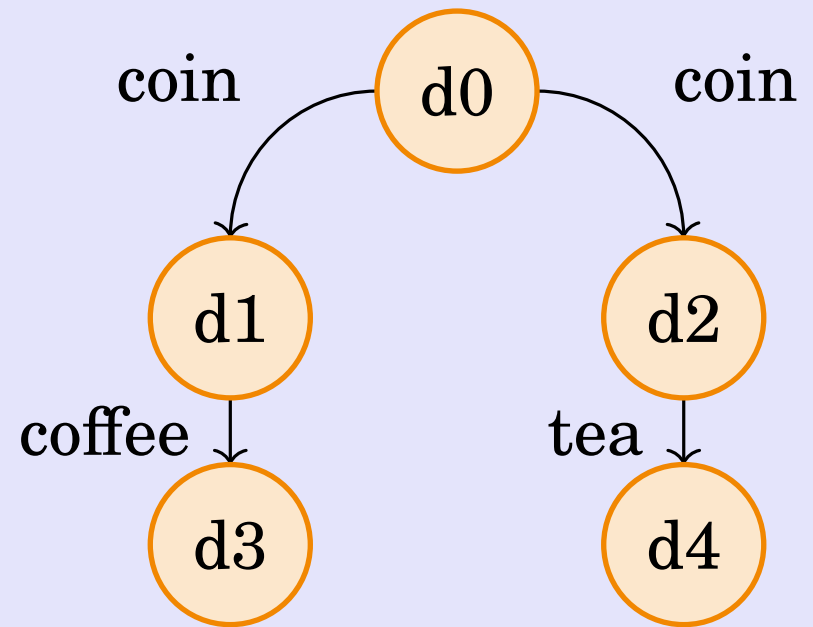


Distinguishing Formulae

Coffee machine C



Coffee machine D



$$\varphi := \langle \text{coin} \rangle (\langle \text{coffee} \rangle \top \wedge \langle \text{tea} \rangle \top)$$

$$c0 \models \varphi \text{ but } d0 \not\models \varphi$$

Relational Connectors¹

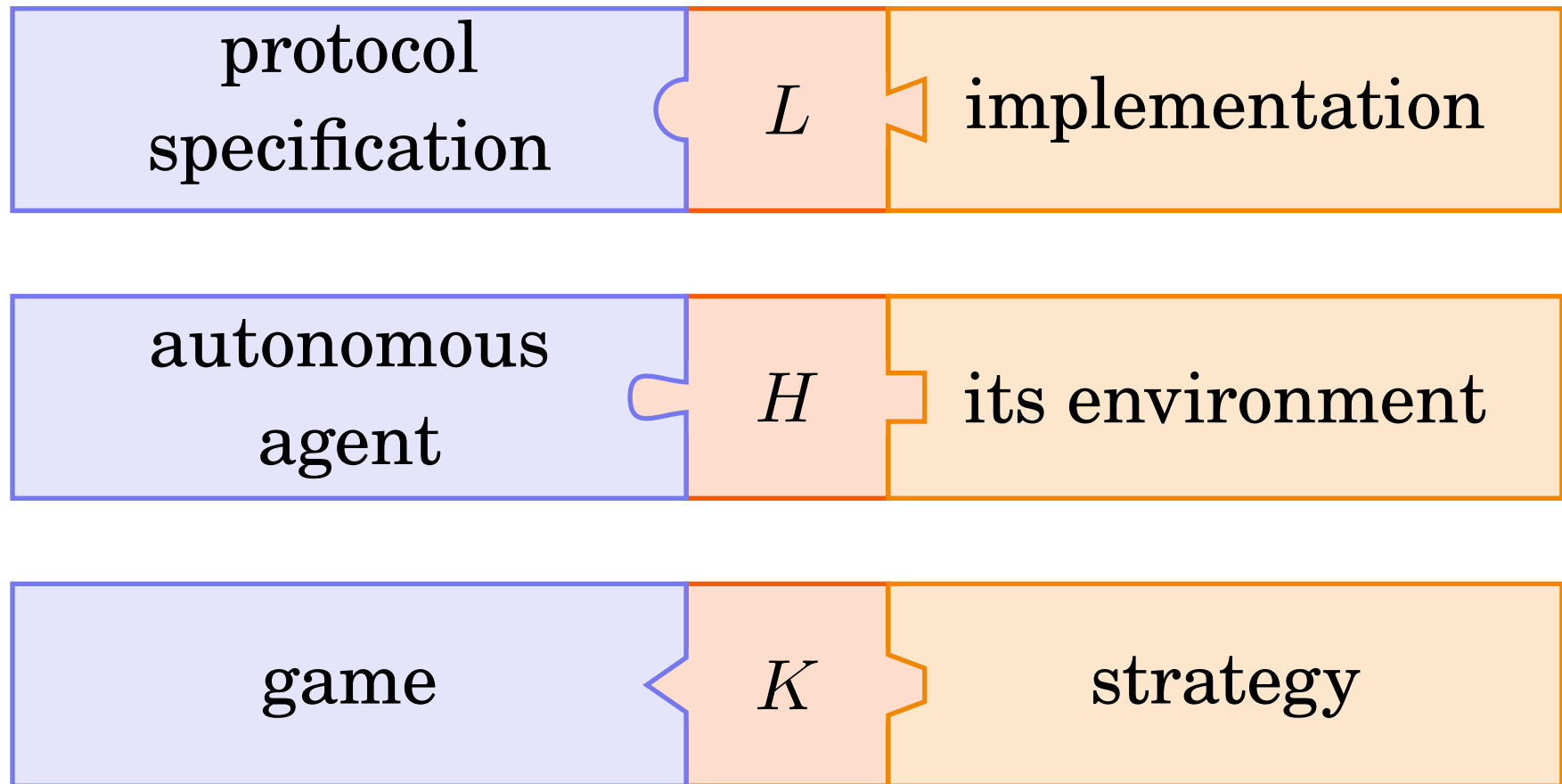
... connect systems of heterogeneous *type*

**Jetzt neu:
Gardena auf Starkstrom!**



¹(Nora, Rot, Schröder, Wild 2025)

Why Relational Connectors?



Unary Logic

Idea

- Give semantics for left and right type
- interpret a formula in both, individually

Specification $\leftrightarrow$ Probabilistic Implementation

If a property holds in the specification, it holds in the implementation with probability ε

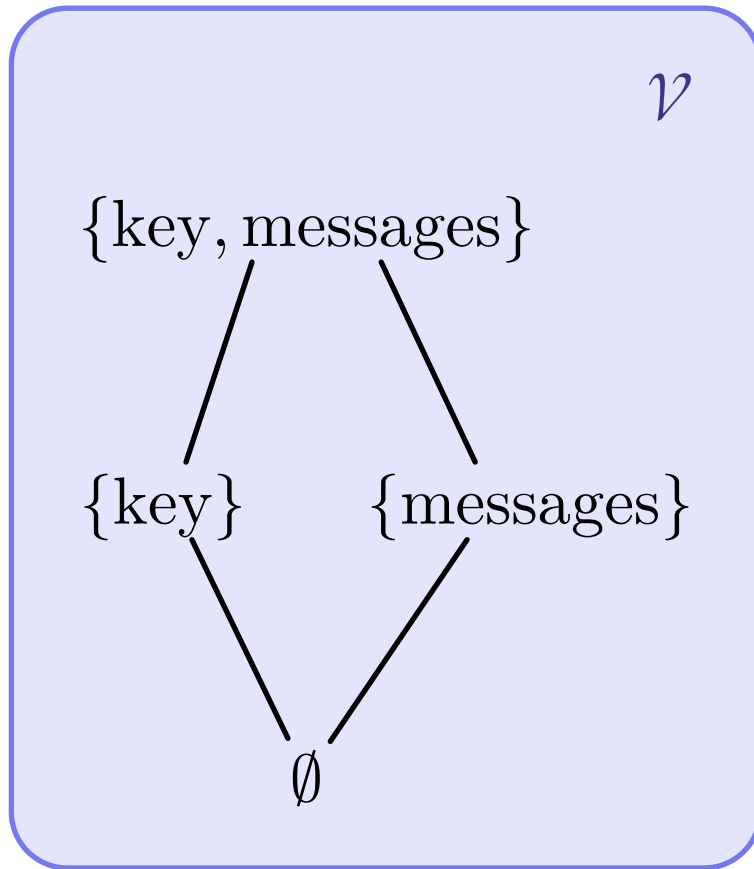
Costa Quanta?

So far, we can only answer *yes / no* questions

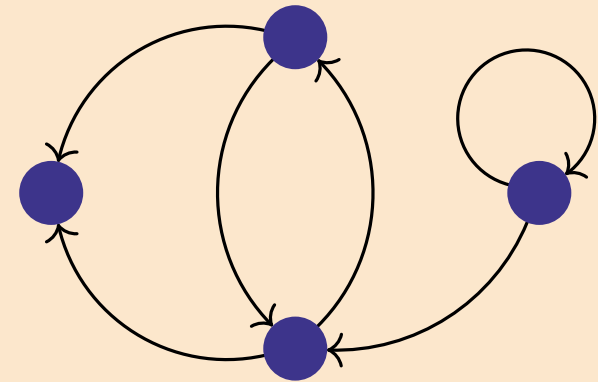


What if we want more granularity?

Quantitative Information Flow



Phantomchat



How much information does the program leak?

Quantitative Relational Connectors¹

Goal

Generalize relational connectors from two-valued to quantitative

Setting

What structure is needed to make it quantitative?

Generalization

How do the known results generalize?

¹joint work with Pedro Nora, Jurriaan Rot, Lutz Schröder, Paul Wild

Dissertation Plan

Quantitative Relational Connectors

1

What happens with relational connectors in a quantitative setting?

2

Logic & Model Checking

What properties do the arising logics have?

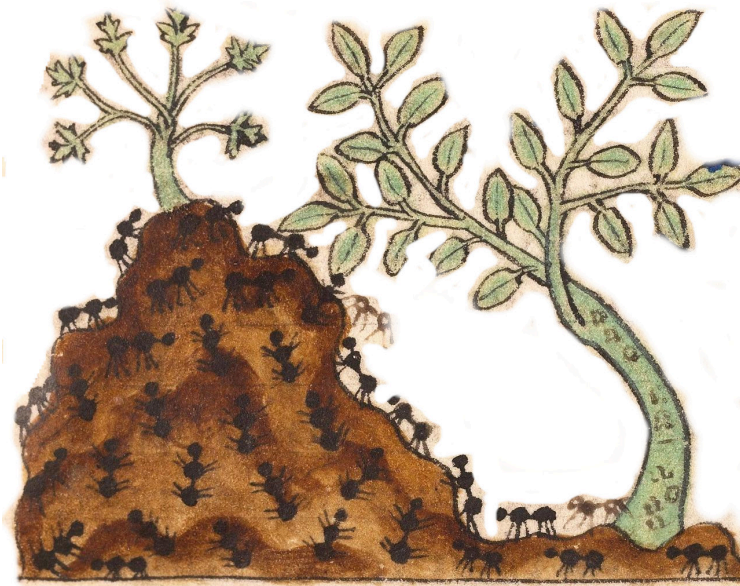
3

***Unspecified* Further Work**

4

Submission in 2028

Future Plans



Binary Logic

Idea

Talk about properties that walk through both systems in lockstep

Problems

more complicated metatheory (expressivity)

But

Enables interesting applications

Strategies in Safety Games

Safety Game

Eloise plays against Abelard. She wins if she can stay in the safe region forever.

Goal

Neatly express when a strategy wins a game position:

$$\nu r. \text{ safe} \wedge \Box r$$



Information Flow

Idea

$\forall\forall$ -hyperproperties look similar to the binary logic

Problems

- information flow research is mostly focused on trace semantics
- limited to $\forall\forall$ -fragment

But

- $\forall\forall$ -fragment covers important properties like **observational determinism**

Further Work

Theory

- Binary logic
- Model Checking

Applications

- Information Flow/ Hyperproperties
- Quantitative Information Flow $\Rightarrow$ Quantale of Information¹
- Differential Privacy

¹(Hunt, Sands 2021)

Dissertation Plan

Quantitative Relational Connectors

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