



Towards Modeling Dynamic Behavior with Integrated Qualitative Spatial Relations

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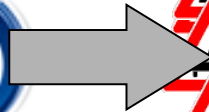
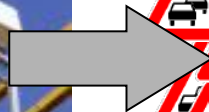
ER 2011, Brussels, Belgium
November 1st, 2011



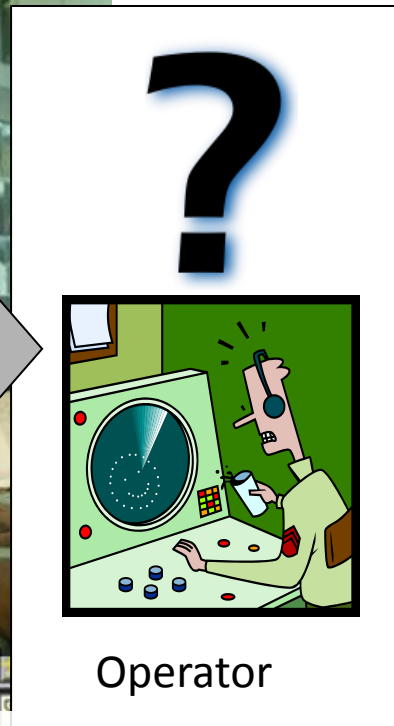


Agenda

- Motivation
- Combined Dominance Spaces of Multiple Calculi
- Case Study in Road Traffic Management
- Implementation of Combined Dominance Spaces
- Summary and Future Work



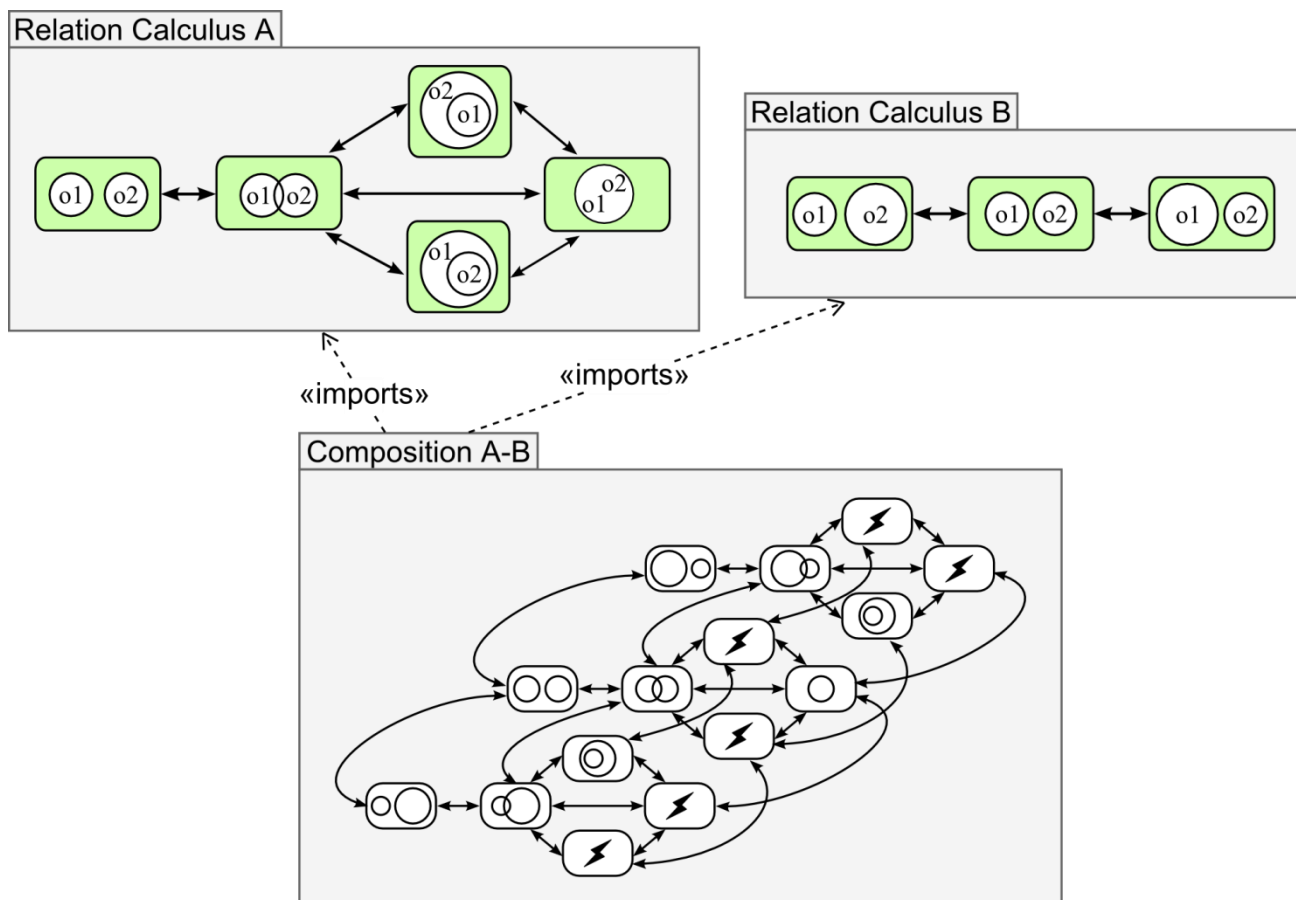
- Objects anchored in **time and space**
- Geographically widespread
- Only **partially observable**

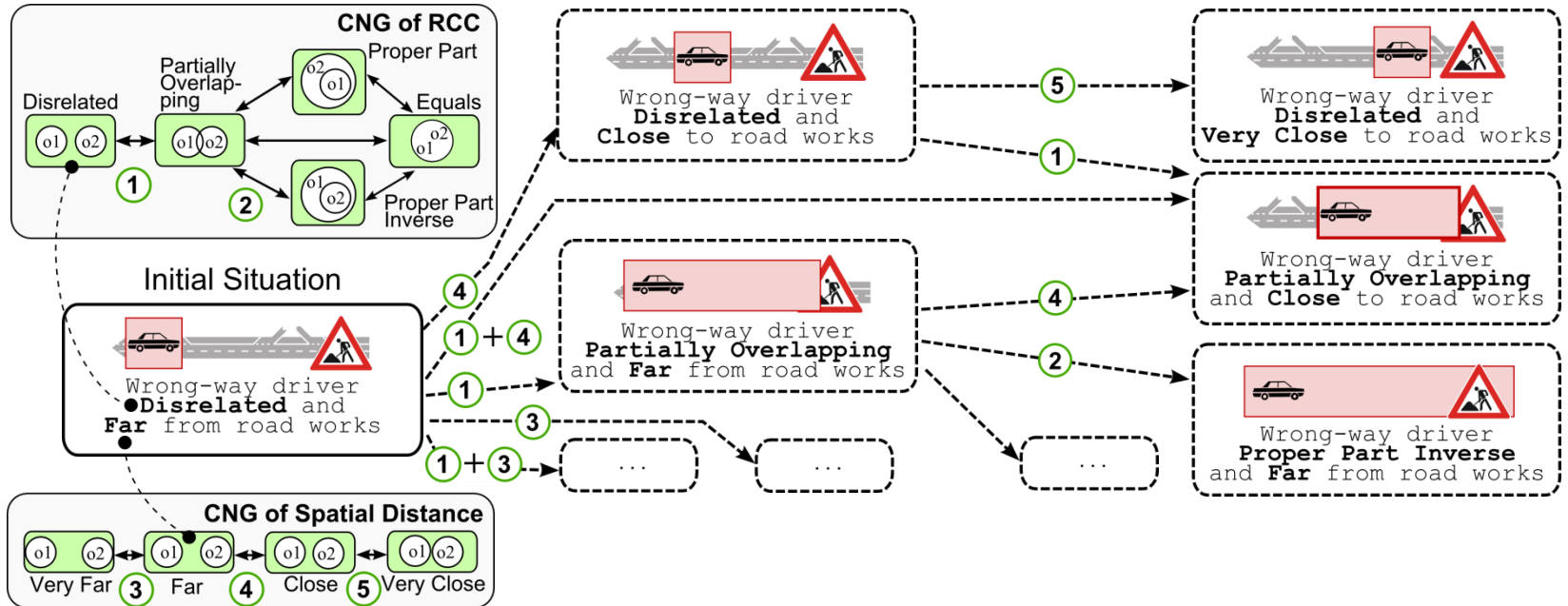


Operator

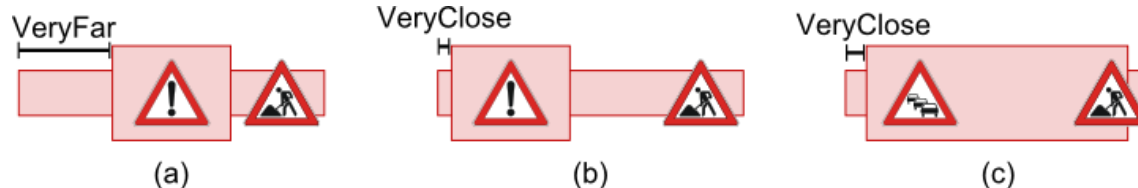
- **Information overload**
- Human operators **lack situation awareness**
- Human operators struggle to **anticipate possible future situations** in order to pro-actively prevent critical situations

- Use case: dynamic reasoning
- The problem: composition of multiple neighborhood graphs

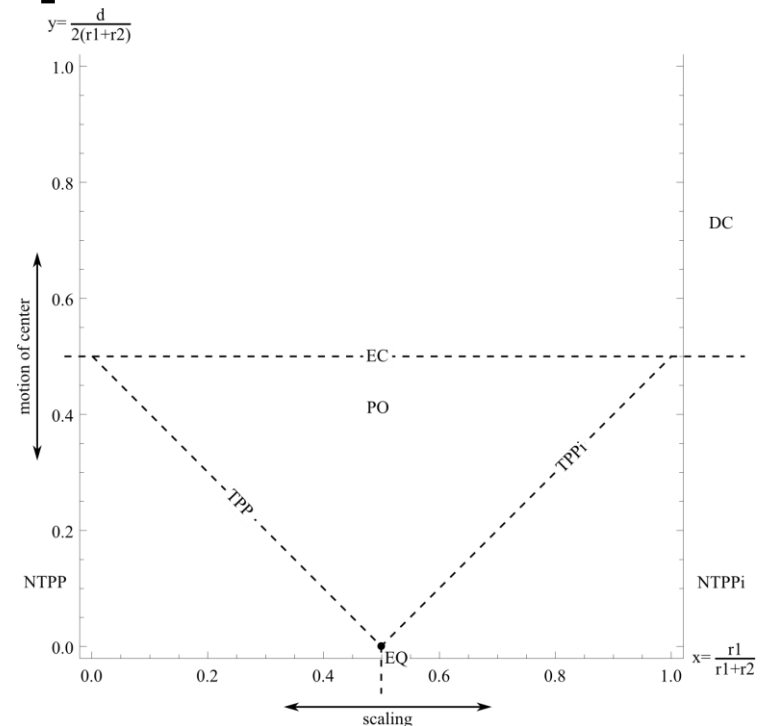


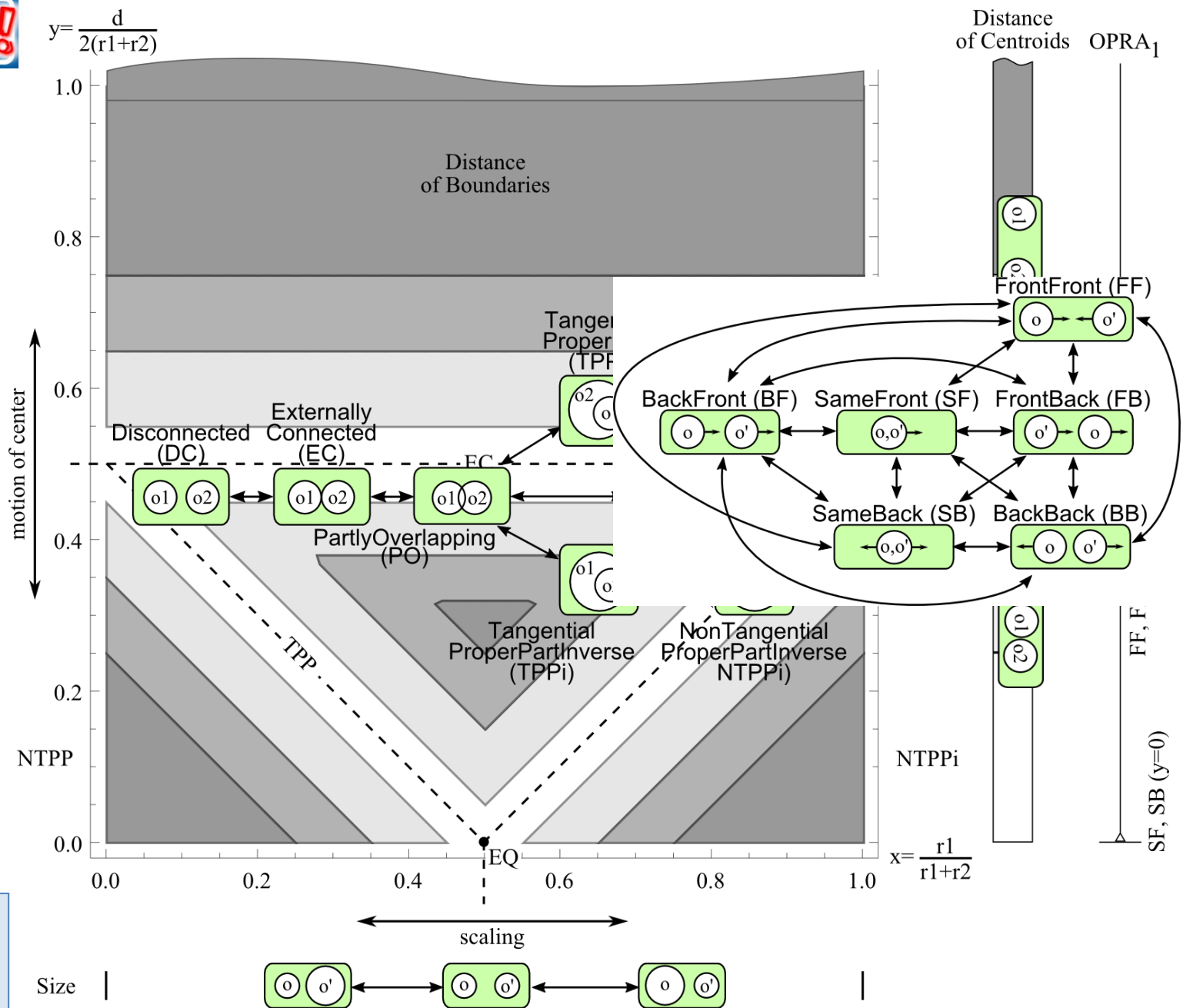


- Composition of different aspects (Topological vs. positional calculi)
- Example: translational motion of differently sized regions

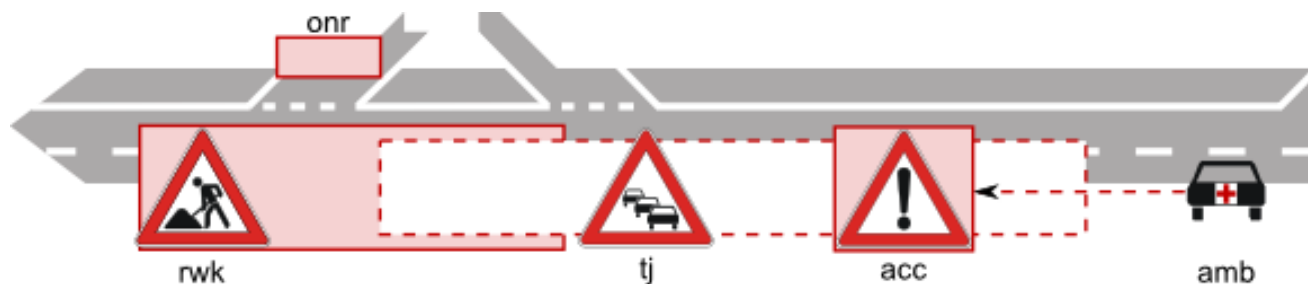


- Encode qualitative relations in a continuous, quantitative space
- Assume spatial primitives (e.g., intervals, spheres)
- Dominance space describes “**full space of possible pairs** of spatial primitives” [Galton, 2000]
- Axis encode relevant object features
- Dominance space describes dominance relationship
 - Some relations may hold only for a **time instant**
 - Others may hold during a **time interval**

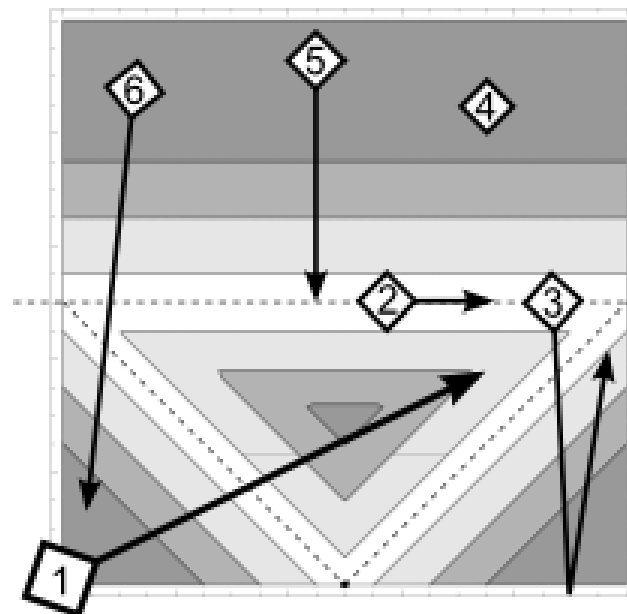




Galton. Continuous Motion in Discrete Space, 7th Intl. Conference on Principles of Knowledge Representation and Reasoning, 2000



- **(1)** Traffic jam (tj) starts at center of roadworks (rwk) and grows towards end
- **(2)** Traffic jam stays connected to on-ramp (onr)
- **(3)** Accident (acc) occurs at end of traffic jam, traffic jam grows to contain it
- **(4)** Accident is stationary with respect to roadworks
- **(5)** Ambulance (amb) drives towards accident
- **(6)** Ambulance drives into traffic jam

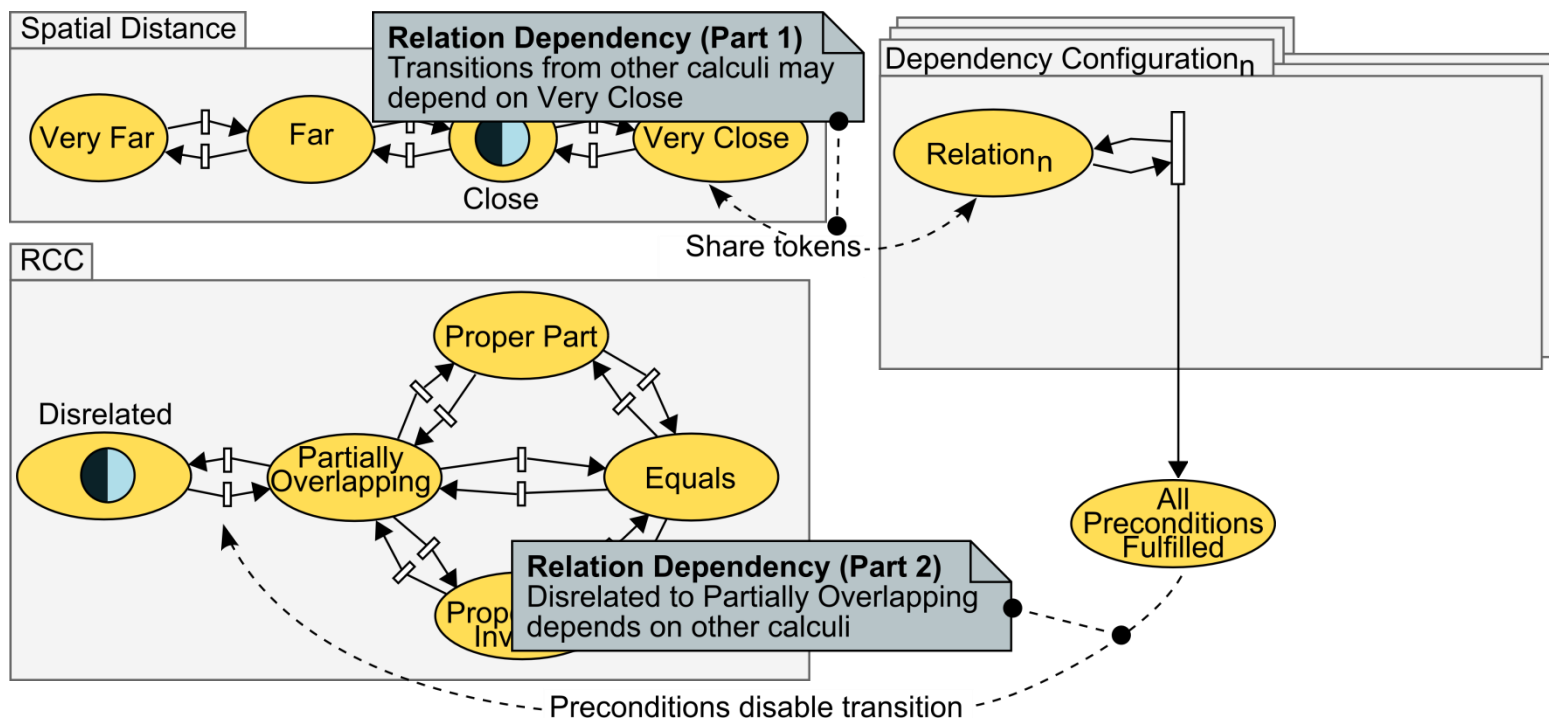


- Situation Calculus
 - Continuants (e.g., objects)
 - Fluents (e.g., properties of objects, relations between objects)
 - Occurrents (e.g., transitions between relations)

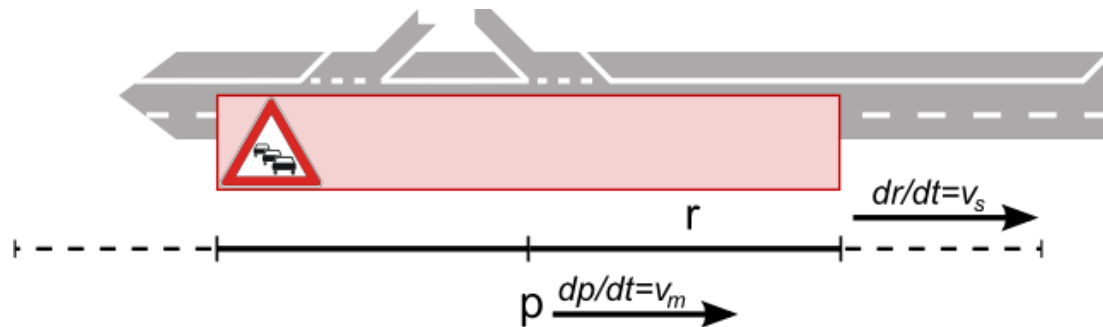
- A transition to EC in RCC-8 is possible, if
 - From a topological view **DC** or **PO** holds,
 - From a distance view **VC** holds,
 - From a size view **any** relation holds

$$\begin{aligned}
 (\Box o, o' \Box O) (\Box s \Box S) \text{ Poss}(\text{tran}(\mathbf{EC}, o, o'), s) \Box \\
 \quad \text{Holds}(\Box_{\text{rcc8}}(o, o'), \Box_1, s) \text{ where } \Box_1 \Box \{\text{DC}, \text{PO}\} \\
 \Box \text{Holds}(\Box_{\text{dist}}(o, o'), \text{VC}, s) \\
 \Box \text{Holds}(\Box_{\text{size}}(o, o'), \Box_2, s) \text{ where } \Box_2 \Box \{<, =, >\}
 \end{aligned}$$

- Dependency pages share tokens between interdependent calculi



- **Transformation** between models of different abstraction and with different purpose
 - Purely qualitative – hybrid – continuous
 - Planning-Projection-Simulation-Verification
- Interpretation of combined dominance spaces as hybrid automata/hybrid Petri nets
 - Evolution of object-pairs in the dominance space can be described in a continuous manner (e.g., differential equations)



- **Generalization to arbitrary calculi** (e.g., different spatial primitives)



Thank you!

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Implementation in Colored Petri Nets

- Dependency pages share tokens between interdependent calculi

